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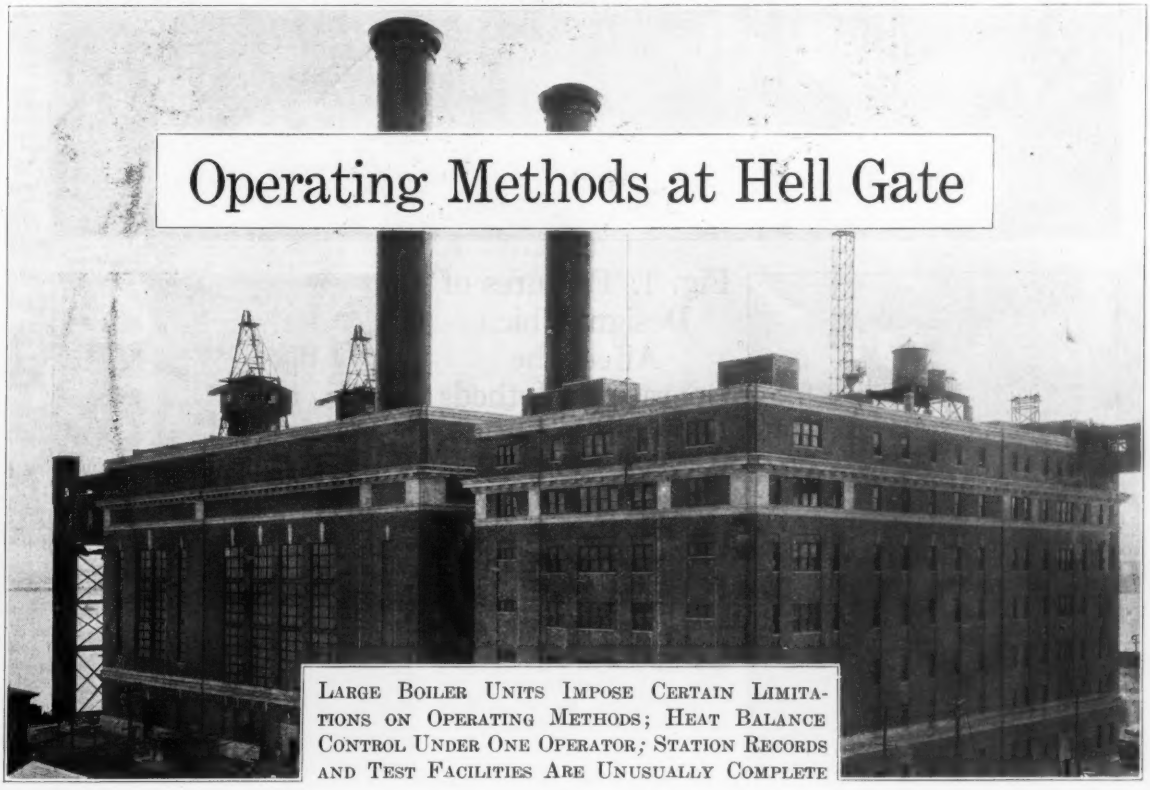


Operating Methods at Hell Gate

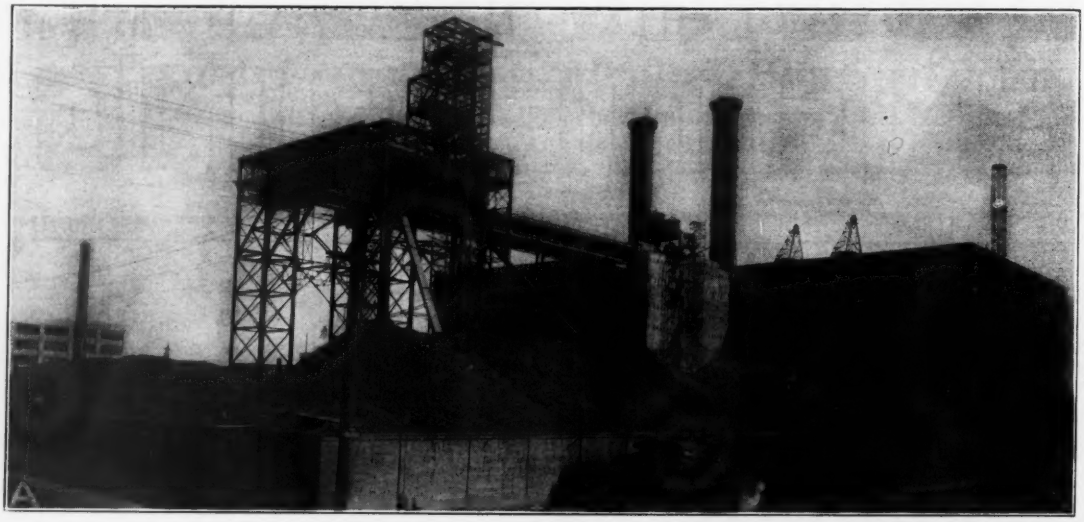
LARGE BOILER UNITS IMPOSE CERTAIN LIMITATIONS ON OPERATING METHODS; HEAT BALANCE CONTROL UNDER ONE OPERATOR; STATION RECORDS AND TEST FACILITIES ARE UNUSUALLY COMPLETE

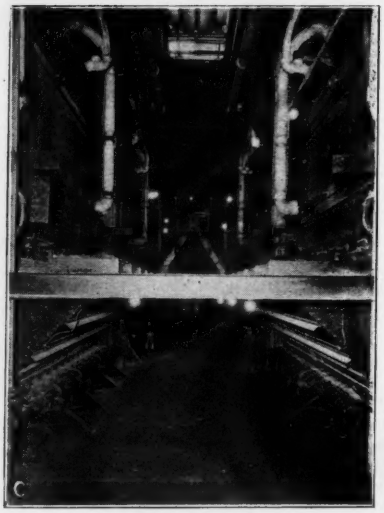
HELL GATE STATION of the United Electric Light and Power Co. in New York City, which has been in operation for about a year and a half, possesses many features of more than ordinary interest. Admirably situated in respect to the growing load requirements of the upper section of the metropolitan district, it further enjoys a unique advantage among the central stations of this locality in regard to the essential items of coal supply and circulating water supply. But aside from the advantages inherent to choice of plant site, a number of other details of its equipment and operation have focused upon it the attention of power plant men in general, so that it has been visited by a great number of American and foreign engineers.

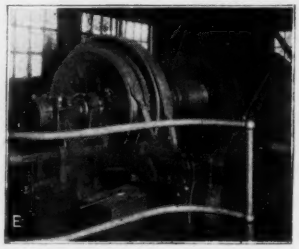
SOME OF THE IMPORTANT FEATURES

AMONG the mechanical features to which reference may be made are the following: provision for unloading ships of 5000 T. and 10,000 T. capacity alongside, as well as for receipt of coal by railroad and for loading barges for supplying the other plants of the system (Waterside and Sherman Creek); provision for checking coal weights at various stages of distribution so that close figures are available at the different steps in the process; disposal of ashes by a sluicing system to a submerged storage pit whence they are removed by gantry to scows or trucks; evaporation of water in a few boilers of large capacity with high settings and equipment of stokers, superheaters, and fans for forced and induced draft; juxtaposition of turbine room to water front, with boiler room between turbine room and switch house, so that the condenser circulating water suction to each pump is taken through a direct inlet from the river, obviating the necessity for a long common intake tunnel; division of the station by the group system into four practically independent plants, two of which are now in full operation; and control of each group through a system of heat balance which insures operation of the equipment at maximum net economy.

Electrical features of particular interest include: phase isolation by vertical walls between the phase switches and other equipment, rendering short-circuits







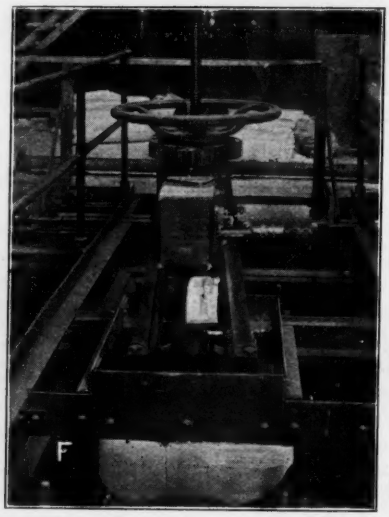


Fig. 1. Features of Design Which Affect the Operating Methods

A. Coal storage at the rear of the station. When delivered by rail coal is unloaded by a locomotive type crane and is hoisted by a skip hoist to cars which transport it to the bunkers. Just above the roof may be seen the coal towers for unloading boats.

B. These coal towers for unloading boats are set 119 ft. above low water. Coal is dropped to trains of eight 4-T. cars which deliver it either to chutes for loading barges, to the bunkers or to the coal storage pile shown in A.

C. Each group of boilers is made up of six 1890 hp. Springfield boilers with Elesco superheaters of 2135 sq. ft. heating surface, having two drums on opposite sides of the setting.

D. Two 14-retort Taylor stokers supply each furnace.

E. One of the coal hoist motors and drives.

F. Eventually all valves in headers of 10 in. or larger will be motor operated.

involving more than one phase practically impossible; operation of this switchgear from the upper floor through a system of rods and bellcranks; operation of auxiliaries, with very few exceptions, by alternating current motor drive, in connection with the heat balance system; use of truck-type switches for house service in connection with auxiliary drive; and provision of a terminal room for control circuits, below the main switchboard.

Coal Handling System Serves Several Stations

With a depth of about 33 ft. alongside at normal low water and a present travel of coal towers of 216 ft., boats of 5000 T. and 10,000 T. capacity may be unloaded without being shifted along the dock. Each of the two travelling coal towers can handle 250 T. per hr., and working together they will discharge a 5000-T. cargo in 19 hr. The track loops of approximately ½ mi. and ¾ mi. length are situated at a level of 119 ft. above low water, the inner track serving the boiler room bunkers while the outer track also extends over the coal storage lots. Eight 4-T. cars are normally operated on each track. Chutes for filling barges destined for the Sherman Creek and Waterside Stations may be served from either track. The supply of these stations from Hell Gate will continue to be normal practice, as it is found to be more economical even to move coal from cargo boats to storage pile and back from storage to coal barges than it would be to handle the situation as is sometimes done by unloading directly from cargo boats to barges by floating derricks.

One hoisting engineer is stationed in each tower, and a second man attends to feeding coal to the cars. By means of two controllers and a pedal which operates an electric brake regulating the fall of the bucket, the hoisting engineer exercises control over the travel of the bucket, which is handled at a maximum speed of 30 ft. per sec. The operation calls for close attention, and is accomplished without signals, even in foggy weather. While breaking down a cargo, the cycle from ship to hopper and return is completed in 28 sec.

From the 15-T. receiving hopper on tower, coal is moved by a short conveyor to crusher rolls, whence it is transferred to a small hopper with gates for delivery to the 4-T. track cars. From the cars, it is dumped to (1) the bunkers, situated above the west end of each firing aisle, (2) the chutes for delivery to storage pile, or (3) the chutes for delivery to barges. Small sized coal is also received by rail and unloaded to the storage space by locomotive crane. Distribution in storage is facilitated by means of a two-yard drag scraper, which is also used in conjunction with the skip hoist for reclamation from storage.

Coal taken from the boats is weighed by automatic recording scales as the loaded cars start from the coal tower. A weekly survey is made to determine the weight of coal in the bunkers, and this is found to check closely with the records of delivery to bunkers and consumption in furnaces. The latter records are made by larry operators, who weigh coal (1) as taken from bunkers and (2) as delivered to individual stokers. For this purpose, two sets of numbered cards are handed to the larry operators daily; and they are held personally responsible for the return of all cards. Sampling for analysis is done automatically from the

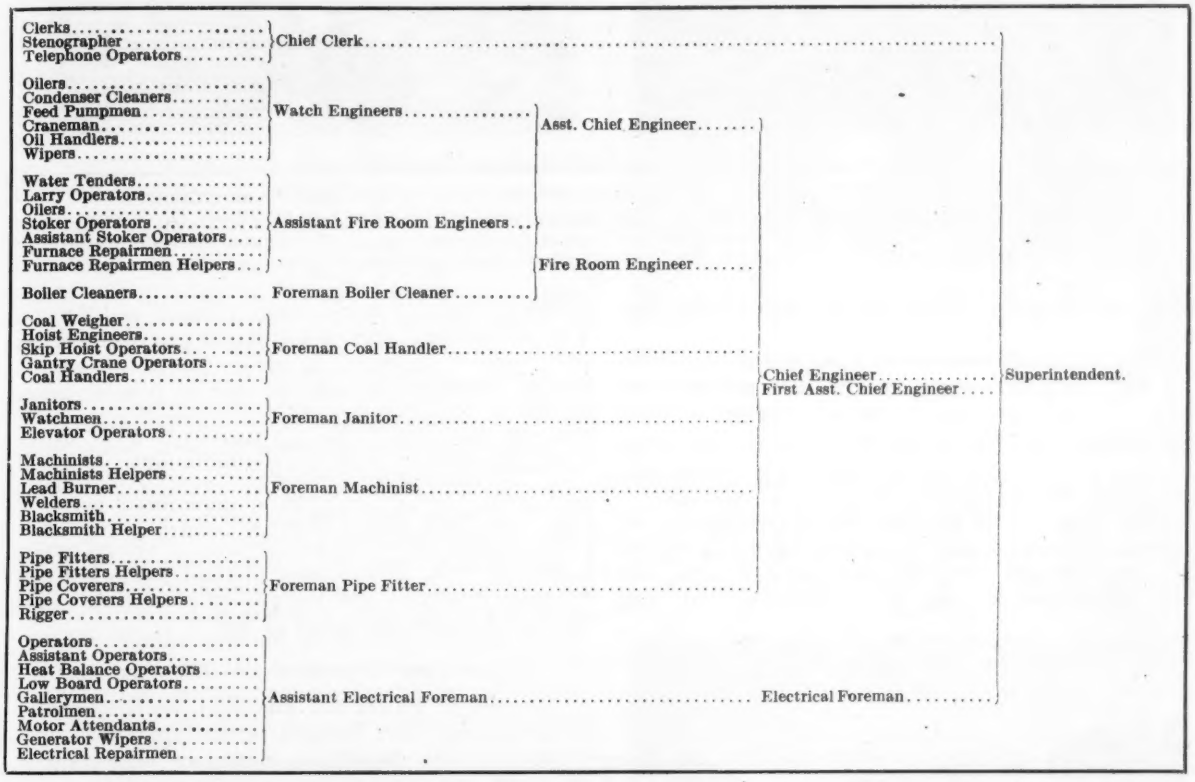


FIG. 2. BOTH STEAM AND ELECTRICAL END OF STATION ORGANIZATION IS UNDER ONE SUPERINTENDENT

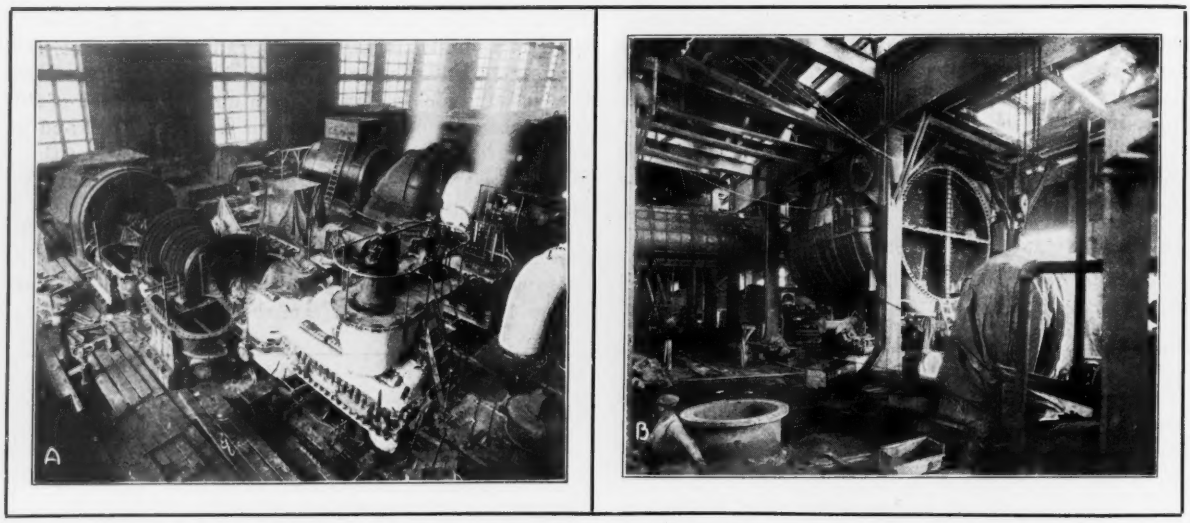


FIG. 3. TWO UNITS WITH THEIR AUXILIARIES AND BOILERS MAKE UP THE GROUP ARRANGEMENT

A. Westinghouse turbine during course of erection, showing low pressure spindle. In the background is the General Electric turbine which is the other unit of the group. These are 35,000 kw. machines. B. Condensers are arranged with a divided water box which permits cleaning one-half without removal from service. Both circulating pumps can discharge to either side of condenser.

track cars, both on receipt and on reclamation from storage.

All coal handling equipment is subjected to continuous inspection, and repairs are made whenever necessary. The record of cables for all purposes is made a subject of particular attention.

Pioneer Installation of Ash Handling by Sluices

This was one of the first central stations in the country to install a sluicing system for ash handling. Tile lined troughs were originally employed, but have been supplanted by cast iron. Ash delivered from clinker grinders is run to a common header, and through it to a submerged storage pit of 700 cu. yd. capacity, from which it is loaded by gantry crane to scows or trucks. Provision is made, in case of possible interruption of service at any point, for dumping the ashes direct to the boiler room basement floor, where water is drained through gratings while the refuse is removed by trucks; the employment of this alternative has, however, been very rare. Three 5000-g.p.m. centrifugal pumps supply salt water for the sluicing system, under a head of 60 ft. Two or three of these pumps are now normally in service, and the present practice is to use 400 lb. of water per pound of ash.

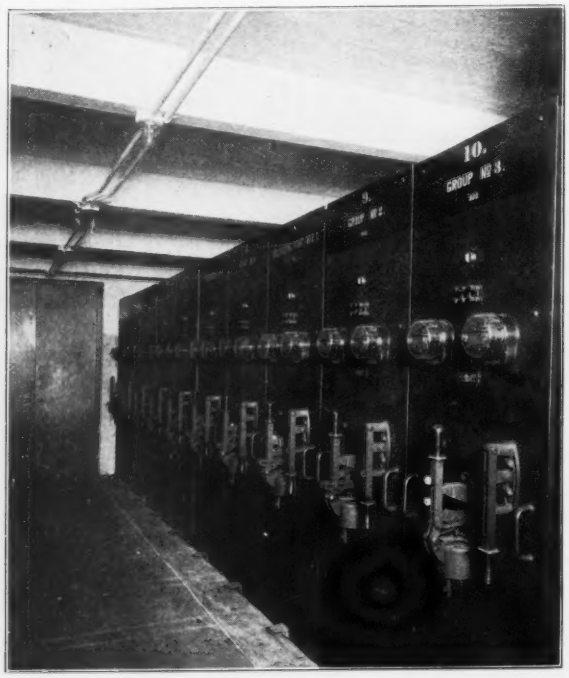


FIG. 4. AUXILIARIES ARE CONTROLLED FROM THIS TRUCK TYPE SWITCHBOARD

Boiler Room Operation and Maintenance

The size of boilers and attendant complications of furnace design have imposed certain limitations upon operation, while simplifying matters in other respects. With only twelve boilers for a present installed capacity of 150,000 kw. in the turbine room, the loss of one boiler becomes a matter of serious importance if two or three other units are already unavailable. It is therefore imperative that all equipment be maintained in the best possible condition. Renewals of certain parts, such as stoker crankshafts, may be made with comparatively little difficulty; but the failure of furnace brickwork or stoker tuyeres, involving removal of the boiler from service, gives more trouble. All such work is done as promptly as possible. Once a year, each boiler is thoroughly overhauled, including cleaning of the inside of the drum and all tubes. Interior cleaning of the bottom rows of tubes, as far up as the superheater, is done as often as circumstances permit.

Blowing down of gage glasses is done by the incoming watch every 8 hr. The boilers are equipped with Diamond soot blowers, and these are operated daily on all boilers on line by the first watch. This watch also tests the concentration of water in each boiler. Provision is made for measuring all blowoff water, so that the heat loss from this source may be accurately computed.

There are eight pop safety valves of the Consolidated Safety Valve Co. make on each boiler. A weekly inspection and test of these is made by the fire room engineer. The S. C. feed water regulators are also inspected periodically.

Very little feed water treatment is required, as the city water used for make-up is of very good quality. Soda tanks are provided for use as necessary. As stated elsewhere, the make-up water amounts at present to only about 2 per cent of the total feed water.

As a guide to operation, each boiler is equipped with two Bailey meters, one of which gives the steam flow from one of the two superheater drums, while the other shows (1) total steam flow, (2) total air flow, and (3) flue temperature. The latter is so calibrated that the ideal condition is reached when the blue line indicating air flow and the red line indicating steam flow coincide. If the blue line falls below the red, there is deficiency of air, indicating incomplete combustion; if above, excess air is present.

Forced draft pressures generally range between one and two and a half inches of water, with the average well below two inches. The coal runs about 14,000 B.t.u. per lb., with an average ash content of about 6 per cent. The average flue gas analysis shows approximately 14 per cent of CO_2.

All gate valves in headers of 10 in. or larger diameter will eventually be motor operated. Opening of these valves must be done manually, but they may be closed from the operating floor or from groups of switches located in the induced draft gallery.

Stokers which are of the Taylor multiple retort type may be operated at speeds varying between ¼ and 1 r.p.m. at the crank shaft. The view shown in Fig. 1 gives an idea of the interior furnace arrangement, with two 14-retort stokers and two clinker grinder rolls per furnace. Clinker grinders are normally run at 1 r.p.m. but this speed may be doubled if required. The rolls and bearings are continuously cooled by water jets. Provision is made for adjusting the crusher aprons and dropping the ashes in case of clinker bridging over the crusher rolls.

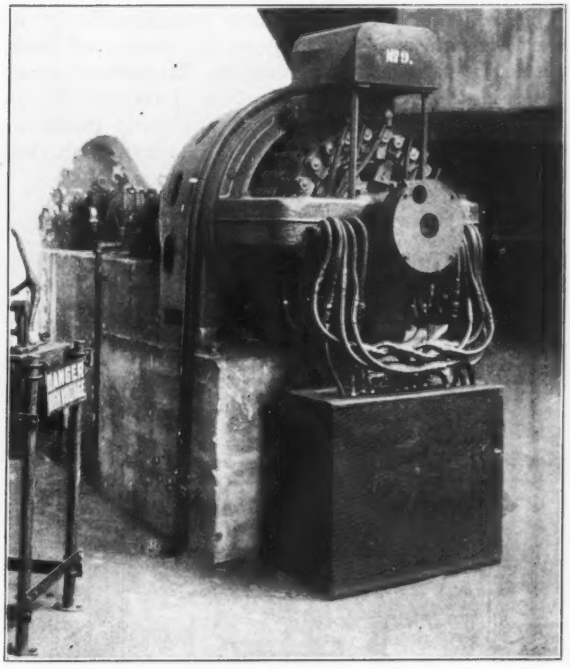


FIG. 5. INDUCED DRAFT FANS ARE DRIVEN BY ALTERNATING CURRENT MOTORS OF THE BRUSH SHIFTING TYPE

Diagrams of feed and steam piping for one group, reproduced in Fig. 10, illustrate the simplicity secured by the group system. Boiler room operation, exclusive of maintenance and repair work, requires but seven men on each watch—an assistant fire room engineer, a water tender, and five stoker operators and assistant stoker operators. There is also a larry operator on each watch to take care of the distribution of coal to the boilers.

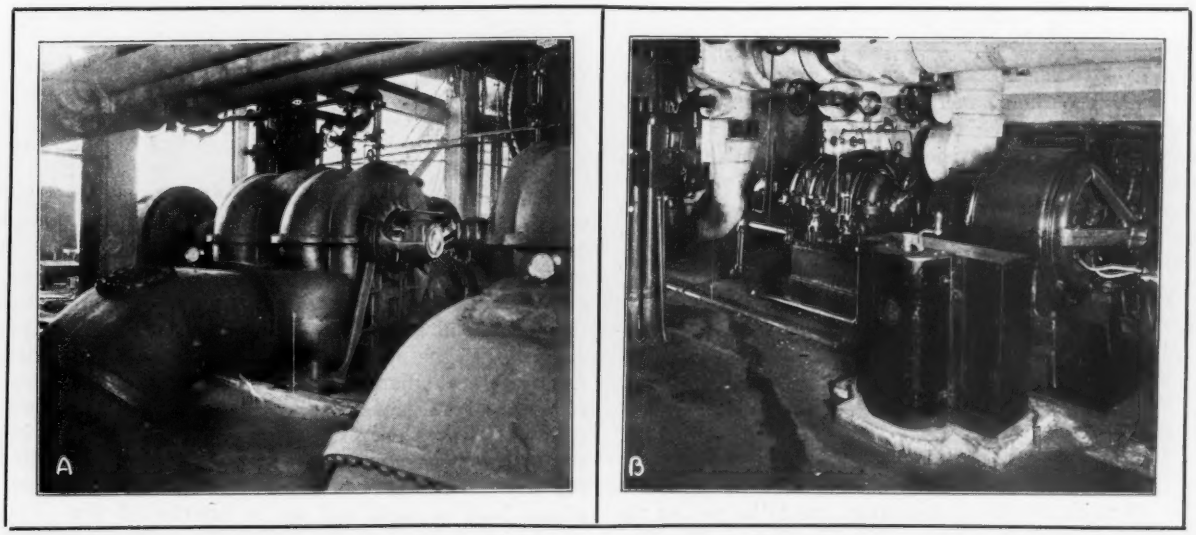


FIG. 6. ALTERNATING CURRENT MOTOR DRIVE FOR AUXILIARIES IS A FEATURE OF INTEREST AT HELL GATE

A. This is one of the condenser circulating pumps which draw cooling water direct from intakes, which are located along the whole water front of the station. B. Boiler feed pumps are driven by alternating current motors of the wound rotor type.

Smoke observations are made continuously by an observer on the roof, who reports the density of smoke emitted from each stack, using the Ringlemann chart, and recording his observations at intervals of one minute. It is probable that an automatic smoke recorder, taking care of itself by light reflection, will eventually supplant the observer on the roof.

Single Shaft Turbines Show High Economy

Under normal conditions, the turbines are opened annually for examination and repair. This work is done under the supervision of experts from the manufacturers of the machines.

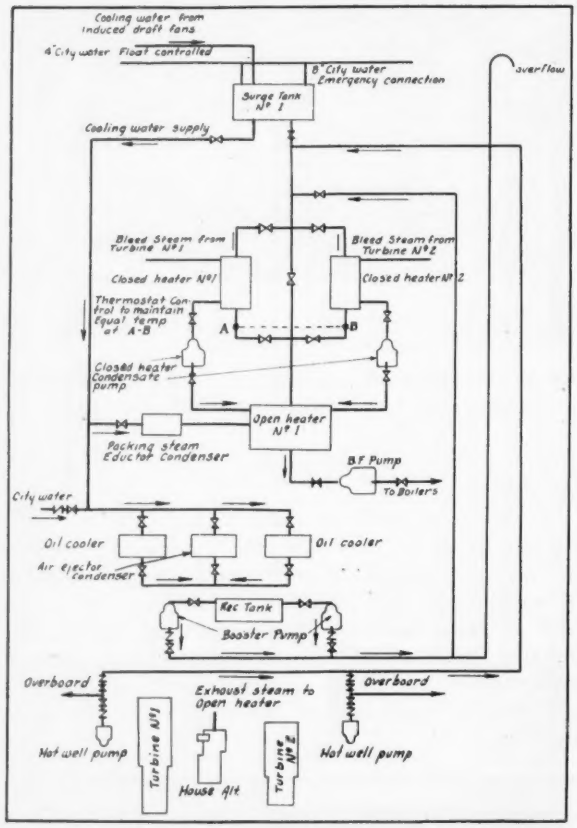


FIG. 7. BOTH BLEEDER AND EXHAUST STEAM ARE USED IN THE FEED WATER HEATING SCHEME

Guaranteed water rates on these machines, for steam at 250 lb. gage and 200 deg. F. superheat at the throttle and exhaust to 1 inch absolute pressure are given below:

Westinghouse Turbines		General Electric Turbines	
Load—kw.	Lb. per kw.-hr.	Load—kw.	Lb. per kw.-hr.
15,000	11.15	20,000	10.85
20,000	10.75	27,500	10.30
28,000	10.40	35,000	10.65
35,000	10.65		
40,000	10.90		

In addition to the batch system of oil filtration for all units, De Laval separators are to be put on the General Electric machines, giving continuous filtration.

As previously stated, the condenser circulating pumps draw cooling water direct from the intakes, which are located along the whole water front of the station. Intake screens are of galvanized iron, put together with phosphor bronze bolts and nuts with countersunk heads. The metal is ½ in. thick, and openings are ½ in. by 6 in. Duplicate screens are provided, so that one set may be lowered when it is desired to clean the others; but the velocity of intake water is very low, and it has not yet been necessary to clean the screens since starting.

Water boxes are divided vertically, and either circulating pump can discharge to the adjacent half or to the entire condenser. Cleaning of water boxes and tubes may therefore be done while the condenser is running, though on account of reduced vacuum the cleaning of tubes with water box divided in this way is done only in case of emergency. In cleaning tubes rubber plugs are employed, and are forced through by air or water pressure. This is done weekly on all condensers. The water boxes are cleaned frequently. Examination of circulating pump impellers and of dry vacuum and hotwell pumps is done as often as possible.

An electrical recorder shows the salinity of water in the main hotwell line. As a further check, to determine which condenser is leaking or the relative condition of each, hotwell water from each machine is tested every half hour, using the usual titration method. If any leakage is evident, the condenser is tested. Little trouble, however, has been experienced from this source.

Heat Balance Secured with Practically All-Electric Auxiliary Drive

Of ultimate importance as affecting the economy of the station as a whole is the system of heat balance or co-ordination of elements entering into the problem of obtaining maximum utilization of the heat input into the plant in the form of B.t.u. in coal delivered to the stokers. This problem has to do with the elimination of losses which are broadly classified under four heads—stack losses, radiation, losses through condenser, and losses in exhaust steam. Its solution according to the best present practice is closely connected with the method of driving auxiliaries. In the design of this plant, consideration was given to five types of auxiliary drive, as follows: all steam; steam and direct current; steam and alternating current; direct current; and alternating current. The last of these was selected as most suitable, and two sources of alternating current at 60 cycles and 2300 v. were provided:

(a) Generator bus, supplied by a house alternator for each group, which delivers current at 2300 v.

(b) Transformer bus, deriving current from the main 60-cycle generator bus through step-down transformers.

Except for one boiler feed pump for each group, an exciter for each house alternator, and one fire pump for the station, all auxiliaries are motor driven. With the exception of the motors on cranes, skip hoist, and coal towers, all auxiliaries may derive their power from either the house generator bus or the transformer bus through 2300-v. truck switches which are located in the boiler room basement. The truck switches connecting any given auxiliary unit with the two busses are placed back to back, and are so interlocked that it is possible to have a motor connected to either bus, but impossible to make connection to both busses at the same time. After connection to either bus is made, an oil switch on the truck must be operated before cur-

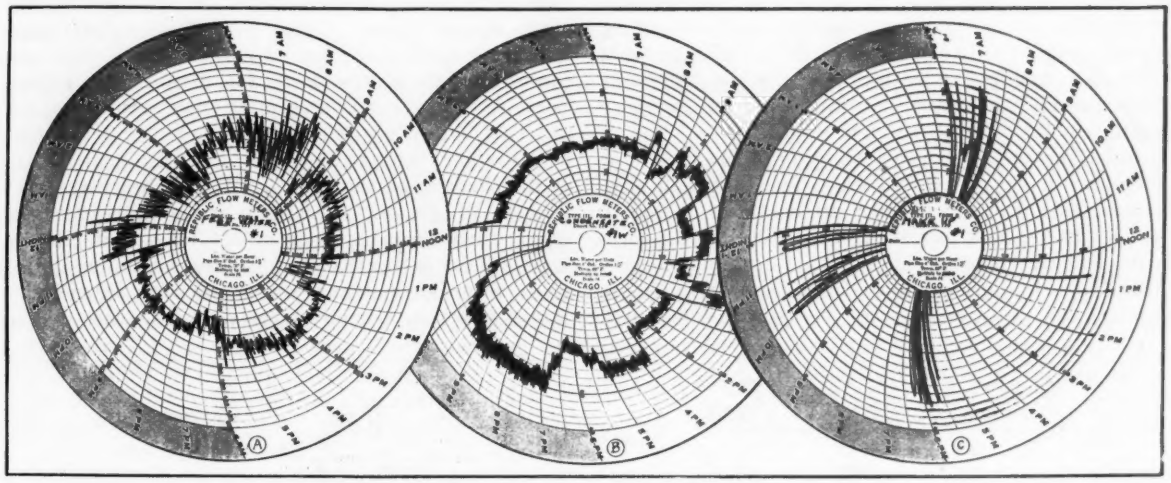


FIG. 8. WATER VARIATIONS ARE CHECKED BY RECORDING METERS

In checking the variations of feed water make up and condensate there are five meters for each group. In A is shown the feed water record for the first row of boilers in the first group. Another meter is used on the second row. B is the condensate for the Westinghouse turbine. A similar record is kept of the General Electric turbine which is the other unit of the group. In C is shown the make up for the group which amounts at present to only about 2 per cent of the total feed water.

rent can be fed to the machine. The truck switches are so designed as to be interchangeable in case it is desired to renew a switch with another from a different part of the board.

Motors driving the forced draft blowers and induced draft fans are brush-shifting, variable speed machines. Variable speed induction motors are used for the boiler feed pumps. Two-speed induction motors are employed for the clinker grinders. All condenser auxiliaries—circulating, dry vacuum, and hotwell pumps—as well as other auxiliaries throughout the station, are driven by constant-speed squirrel-cage induction motors. In the case of stoker drive, variable speed is obtained through Lewellen variable speed transmission machines.

The system of feed water heating for each group involves both main units and the house alternator of the group; two closed heaters of 350,000 lb. per hr. capacity; one open heater of 1,000,000 lb. per hr. capacity; a surge tank above the boiler room floor, through which city water for makeup is introduced into the system; and three boiler feed pumps delivering water to six 1890-hp. Springfield boilers equipped with Elesco superheaters and delivering steam at 260 lb. gage and 200 deg. F. superheat under normal operation at 200 per cent rating. The 35,000-kw. General Electric turbine is equipped with an eductor-condenser on the high pressure gland discharge, and air removal from its main condenser is accomplished by means of two

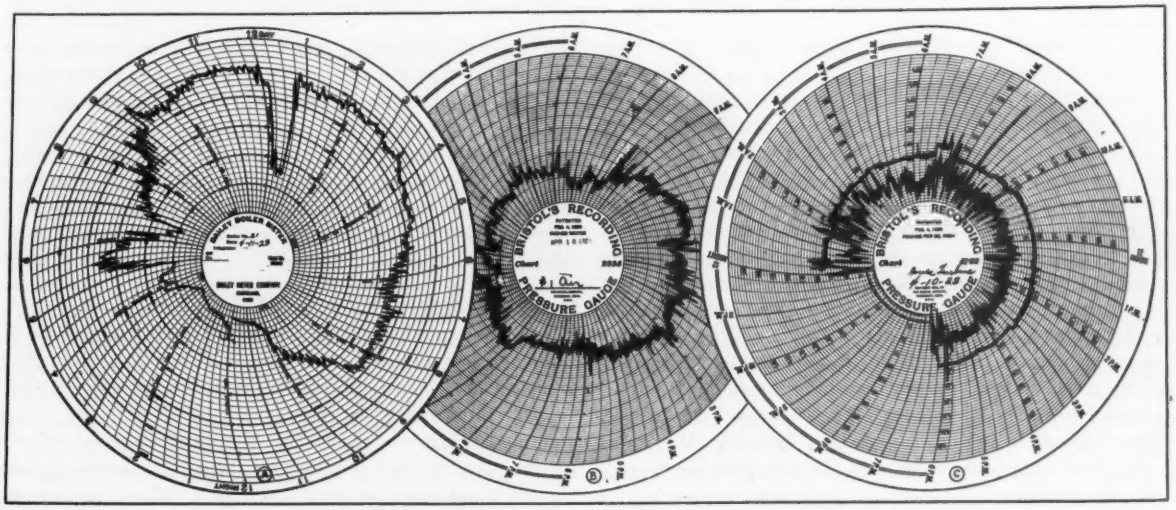


FIG. 9. STEAM GENERATING CONDITIONS ARE ACCURATELY CHECKED

On each boiler there are two flow meters. One checks the steam flow from one of the two superheater drums while the other shows total steam flow, total air flow and flue temperature. Chart A shown above is record of the flow from one superheater drum. There is also a meter for each row of boilers which records the air pressure in the forced draft ducts as shown in B. There is also the usual complement of recording pressure gages for both the main and the house turbines. The chart C is for house turbine No. 1. The lower line is read on the lower scale and is the back pressure while the other curve is the inlet pressure at the secondary valve. Similar charts show inlet pressure to secondary valves on main units of the group.

air-ejector condenser units. Both the Westinghouse and General Electric main units have individual oil cooling systems supplied with cooling water from the surge tank, which also supplies condensing water for the air-ejector condensers and the eductor condenser on high pressure packing on the General Electric unit.

Referring to the diagram of cycle of operation for one group in Fig. 7, hotwell water from the main condensers passes through the two closed heaters, thence to the open heater, and then through the boiler feed pumps to the boilers. Heating in the closed heaters is accomplished by bleeding at about 6.5 lb. absolute pressure from the low pressure stages of the main turbines, each

The instruments on each section of the heat balance board are as follows: Upper row: 3-point draft gages indicating draft above fire in each boiler of each row; recording temperature gage for atmospheric exhaust line; recording and integrating flow meter on city make-up water for the group; and recording feed temperature gage with two pens, showing the temperatures of discharge from the closed and open heaters, respectively. Middle row: Recording temperature gages on superheated steam in leads of the main units; ammeters indicating relative load on the six induced-draft fans; recording pressure gages showing intensity of forced draft in the air ducts supplying each row of

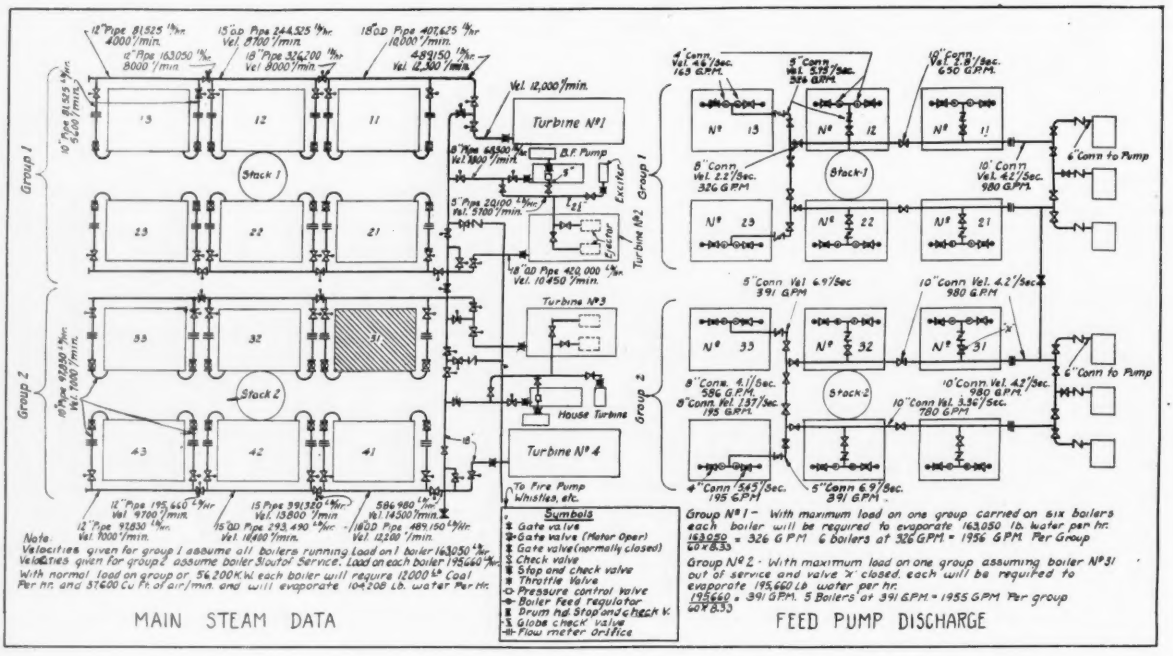

Group 1
Group 2
Stack 1
Stack 2
Turbine N°1
Turbine N°3
Turbine N° 4
House Turbine
B.F. Pump
Exciter
To Fire Pump Whistles, etc.
MAIN STEAM DATA
FEED PUMP DISCHARGE
Symbols
Gate valve
Gate valve (Motor Oper)
Gate valve (normally closed)
Check valve
Stop and check valve
Throttle Valve
Pressure control Valve
Boiler Feed Regulator
Drum hd. Stop and check V.
Globe check Valve
Flow meter Orifice
Note. Velocities given for group 1 assume all boilers running. Load on 1 boiler 163050 Lb/hr. Velocities given for group 2 assume boiler 31 out of service. Load on each boiler 195660 Lb/hr with normal load on group or 54,200 Kw. each boiler will require 12000 Lb Coal Per hr. and 57600 Cu Ft. of air/min. and will evaporate 104208 Lb. water Per Hr.
Group N°1 - With maximum load on one group carried on six boilers each boiler will be required to evaporate 163,050 lb. water per hr. 163050 ÷ 60 x 8.33 = 326 G P M 6 boilers at 326 GPM = 1956 G P M. Per Group
Group N°2 - With maximum load on one group assuming boiler N°31 out of service and valve N° closed, each will be required to evaporate 195,660 Lb. water per hr. 195660 ÷ 60 x 8.33 = 391 GPM. 5 Boilers at 391 GPM = 1955 GPM Per group

FIG. 10. GROUP ARRANGEMENT IS TO BE NOTED IN THE LAYOUT OF STEAM AND FEED PUMP PIPING

of which normally supplies one closed heater. The load on these heaters equalize.

The open heater receives its primary supply of heat from the 2000-kw. house turbine, which exhausts to it at a pressure of about 1 lb. gage. In case this is insufficient, recourse is had to bleeding from the main turbines at points where the pressure is correspondingly higher than that of steam bled to the closed heaters. Heat from the oil coolers and from the air-ejector condensers of the General Electric unit is conserved by discharging the cooling water from these sources to a receiving tank, whence it is transferred by booster pumps into the supply line to the closed heaters, which also receives makeup water from the surge tank. The eductor-condenser on the high pressure packing of the General Electric turbine discharges direct to the open heater, and condensate from the closed heaters is pumped to the open heater.

Complete control over this system is exercised by an operator in the heat balance room which is located above the main turbine floor. The house turbine switchboard is located on one side of this room, and the heat balance board on the other side. The heat balance board contains a panel for each group, boilers; and indicating gage for pressure in the main steam header. Bottom row: Integrating and recording flow meters giving condensate from hotwell of each condenser and water fed to each row of boilers; ammeters indicating relative load on forced draft blowers, with push-button control for regulating the blowers from this point; and recording pressure gage with two pens, giving the steam pressure in main header and feed water pressure.

Heat Balance Controlled by One Man

As stated above, the control of heat balance is in the hands of one man, the heat balance operator, who operates the house alternator switchboard, directs the shifting of auxiliaries from one bus to the other, and watches conditions shown by the heat balance instruments. At his desk is a dummy board, containing holes for all auxiliaries, in which are inserted red, green, or white plugs indicating respectively whether each machine is running from the house generator bus or from the transformer bus, or is out of service or under repair. As the truck switches are of massive construction and fill considerable space, it would obviously be inexpedient to have a separate truck switch for each of

the smaller auxiliaries. The air compressors, ash pumps, booster pumps, exciters, hotwell pumps, motor-generator sets, station lighting units, salt water pumps, vacuum pumps, and cable drives, are therefore arranged in eight groups, each of which is controlled through a single truck switch, so that all units of a group have to be operated or kept out of service.

Probably the reason why one man can look after so much lies in the fact that very little hand manipulation is required. The furnace draft, which is maintained at one or two hundredths of an inch, is regulated by an automatic system. The exhaust steam temperature recorder gives a check on losses through the open heater vent, and in case such losses occur the temperature is reduced by cutting down the amount of bleed steam or by shifting load from the generator bus to the transformer bus, in this way reducing the exhaust steam from the house turbine. The amount of make-up water required is small, rarely exceeding two per cent of the total feed water. Under normal conditions, the closed heater temperature is maintained at a proper value by keeping the low pressure bleeders full open. The high pressure bleeders are regulated by the engineer on watch in accordance with the requirements of the situation, with which he is kept in touch by telephone from the heat balance operator. The heat balance operator is also in direct telephonic communication with the auxiliary room and directs changes of the truck switches by this means.

Steam pressure is maintained from the heat balance board by regulation of the forced draft blowers. Two buttons are provided for each blower, one of which is used for raising the speed and the other for lowering it. The engineer on duty in the boiler room is thus relieved of direct responsibility for keeping up the steam pressure, though he is of course responsible for many contributory details. For instance, the cutting in or out of the induced draft fans is ordinarily left to his judgment. The present system of manual control of forced draft blowers may ultimately be replaced with automatic control.

It is not found necessary to run both house turbines unless all four main turbines are in service; with one, two, or three main turbines on line, one house turbine is sufficient. The system of communication between the house alternator board and the turbine room is similar to that between the main switchboard and turbine room, and the machines are synchronized and cut in on the house generator bus in a similar manner to that employed with the main units. In case both house units are out of service, all auxiliaries may be run from the transformer bus, and if for any reason this bus is out of service, all auxiliaries may be run from the house generator bus. But ordinarily, the auxiliaries are about evenly divided between the two buses, except that equipment in coal towers is run from transformer bus.

At midnight all charts are changed; and the charts for the previous day are turned in to the chief engineer, who inspects them and sends them to the office of the engineer of tests for analysis. Here the information from these charts and from other sources—load records from the switchboard, coal cars from the weigh larries, steam and air flow records from individual boilers and blow down and city water records—is collated and the results are reported on one of the station forms. This particular form supplies a complete summary for the day, including performance in coal consumption per kilowatt-hour, evaporation per pound of coal and per kilowatt-hour, and condensate, make-up water, and city water per kilowatt-hour. Such careful records of actual conditions from day to day contribute no small part toward maintaining performance which is probably unequaled elsewhere in the country.

Test Work Thoroughly Organized

It can readily be seen that a good deal of test work is required in a plant of this type, not only in compiling such daily performance data and in making coal, ash, and oil analyses, and similar items, which after all become matters of daily routine, but in conducting performance tests as required on various types of equipment. All this work is in charge of an engineer of tests with a staff of six or seven men, which, in case of work involving a good many observers, as in acceptance tests for the larger units, is augmented by drafts from other departments of the company.

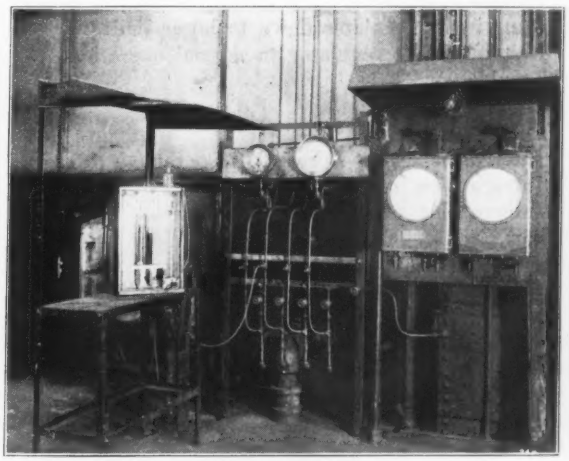


FIG. 11. FLUE GAS SAMPLING APPARATUS ON THE BOILER WHICH IS EQUIPPED FOR TESTING

Equipment for test purposes, beside an up-to-date laboratory with its accessories, includes some special features in the plant itself. A test line is provided into which all condensate from the unit under test may be discharged, all connections to other lines being blanked off. This line discharges to two large weighing tanks in which the water may be weighed without difficulty under the severest load conditions. The operation is accomplished by means of quick opening and closing valves for shifting the discharge from one tank to the other, and Fairbanks scales of high accuracy for weighing each tank. After weighing, the water runs to another tank below the weighing tanks, and is pumped back to the closed heaters. The weighing tanks may also be used for calibration tests on meter equipment, giving results of inherently high accuracy.

One of the boilers is specially equipped for test work. Accurate feed water measurements are secured by a Venturi meter. Four connections for gas samples are provided, with an aspirator for rapid emptying of the sampling lines. There is also a battery of sixteen gages for forced draft observations, with connec-

tions to eight points on each side of the furnace, including extension grates, wind boxes, and main air supply.

As this station forms a part of a power system which also includes the Waterside and Sherman Creek stations, control of the whole system is in the hands of a system operator working from the Waterside Station. Gamewell signal apparatus installed at each main switchboard throughout the system conveys simultaneous notice to each operator concerning trouble and action to be taken. The messages are recorded as sets of holes in a tape, corresponding to standard messages, and a bell rings to give notice of their receipt. The following is a list of the signals in use:

Trouble at Sherman Creek.
Trouble at Waterside.
Indications of trouble. Stand by.
All A. C. supply interrupted.
Indications of approaching storm.
Trouble at Hell Gate.
Run circuit regulator down to lower limit.
Restore circuit regulator to normal operation.
Trouble now O. K.
Conditions satisfactory.
Conditions normal.
Interruption short—probably less than 5 min.
Interruption long—probably more than 30 min.
Interruption of unknown duration.
Time signal. Correct time to 12 o'clock noon.
Test signal.
Cancel last signal.

Besides having the usual general telephone service, the main switchboard operator is in direct telephonic communication with the operators at Waterside and Sherman Creek, and with the turbine room, the heat balance room, and the direct current switchboard. For convenience in starting and stopping the main units, signal stands are provided at each turbine and in the auxiliary room. The communications at starting one of the main units are as follows:

(a) Operator signals "Start Aux." and Turbine No. and blows horn.
(b) Engineer returns "Start Aux." from signal stand indicated.
(c) Operator clears Turbine No.
(d) When ready, engineer signals "Start Tur." and clears "Start Aux." Also rings bell once.
(e) Operator returns "Start Tur." and clears "Start Aux."
(f) When turbine is up to speed, engineer signals "Full Speed" and clears "Start Tur."
(g) Operator signals "Stand By" and clears "Start Tur." He then proceeds to synchronize and put on a load of 3000 to 5000 kw.
(h) Operator signals "O. K." and clears "Stand By."
(i) When engineer is ready for load to be increased, signals "O. K." and clears "Full Speed."
(j) Both operator and engineer clear signals.

Organization of the operating force differs from what is found in most central stations of the district in that a single head—the superintendent—is placed in charge of the entire plant, with the mechanical, electrical, and clerical forces all under his supervision. Figure 2 shows the full organization under the superintendent in diagrammatic form. In the case of the assistant fire-room engineers, these men report to the fire-room engineer when he is on duty, otherwise to the assistant chief engineer on watch. Another unusual feature consists in providing seven men for every six jobs, allowing one day off per week. This applies to all below the grade of foreman, and so far as possible to foremen and engineers as well.

Adequate provision is made for the health and safety of employes. Locker rooms, with lavatories, shower baths and toilets adjacent to them, are located on several floors of the switch house. All lockers are arranged in pairs, for clean and soiled clothes. Drinking water is sterilized by boiling before use, and a refrigerating plant for the purpose of cooling this water is being installed.

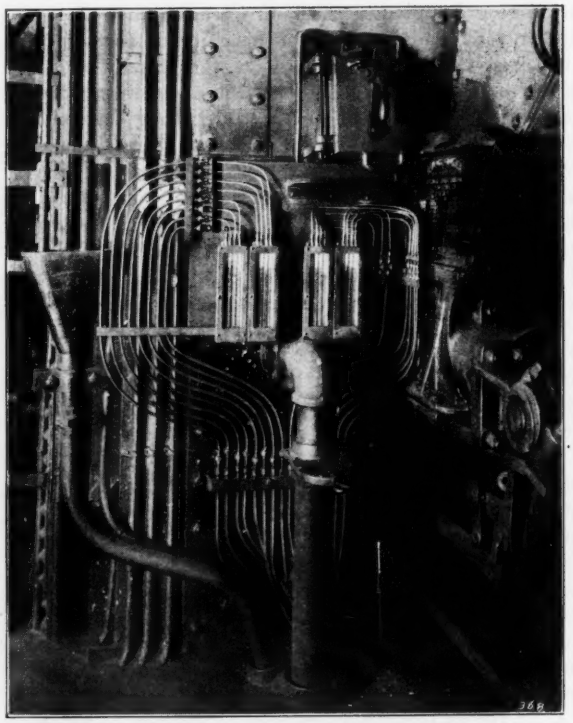


FIG. 12. FORCED DRAFT GAGES ON TEST BOILER

Operation of so extensive an installation, with both 25-cycle and 60-cycle output, involves the use of a large number of forms for adequate record of daily routine and special happenings. Practically every part of the plant has its own story to write, and items which are not automatically recorded are set down by hand. The daily report of main switchboard operators requires an eight-page form approximately 12 in. by 14 in. in size, with provision for hourly meter readings on generators and tie lines, readings on outgoing feeders, general summary of meter readings, load curve, and log of load changes and unusual happenings for the day. Most other operating records are kept on standard letter size paper with perforations for binding.

Acknowledgment is due to Frank W. Smith, vice-president of The United Electric Light and Power Co., to H. W. Leitch, general superintendent of power stations, and to H. Y. Hall, superintendent of the Hell Gate station, for the courtesy and cooperation which have made possible the preparation of this article.

Valves and Piping for High Pressure Steam Lines

STEAM PRESSURES OF 600 TO 1200 LB. AND CORRESPONDINGLY HIGH TEMPERATURES HAVE BROUGHT ABOUT RADICAL CHANGES IN PIPING AND VALVE DESIGN. BY D. H. SKEEN

IT WAS ONLY a few years ago that 250 lb. pressure and about 600 deg. total temperature were considered the limits in power plant practice, and there has appeared in the technical press, from time to time, the statement that the boiler and turbine makers were ready to supply equipment for higher pressure but the valve and piping problems had not yet been solved.

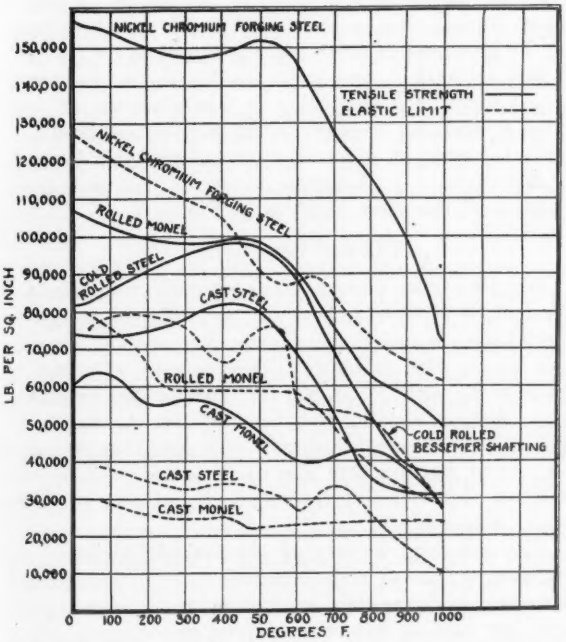


FIG. 1. EFFECT OF TEMPERATURE ON THE TENSILE STRENGTH AND ELASTIC LIMIT OF VARIOUS METALS

Increase in the cost of fuel and labor and other operating expenses, without a corresponding increase in rates, has made increased economy imperative so that we now find several plants operating at 350 lb. pressure and about 700 deg. total temperature, and there are under construction plants for 650 lb. pressure and 750 deg. total temperature. There are even several boilers and turbines being built for 1200 lb., but 750 deg. seems to be the limit of temperature due to a serious decrease in the tensile strength and elastic limit of the metals used at temperatures above this. Figure 1 gives the effect of temperature on the tensile strength and elastic limit of metals used in piping work for the higher temperatures.

In making calculations for materials for use at high temperatures, a factor of safety based on the elastic limit at the particular temperature should be used instead of one based on the tensile strength. This is evident from an examination of Fig. 1 and it is seen that because the elastic limit is half the tensile strength at ordinary temperatures, it does not follow that it is half at the higher temperatures.

For high pressure work, seamless drawn steel tubing will probably be used to the exclusion of welded pipe due to greater uniformity of the metal and less liability to flaws and cracks. In calculating the thickness of the pipe, a factor of safety of about 4, on the elastic limit at working temperatures, should be used and the stress should not exceed about 4000 or 5000 lb. per sq. in.

Velocities used have been increasing for the past few years until a maximum of 14,000 ft. per min. was reached for the header velocity in some of the larger plants. This, of course, was due to the smaller pipe sizes required and to the fact that the pressure drop, due to friction, was converted into temperature increase without loss of heat. For higher pressure work, there does not seem to be a tendency to increase these velocities and a velocity of 7000 to 8000 ft. per min. through the boiler outlet and non-return valve and 10,000 to 12,000 ft. per min. through the headers seem now to be considered good practice.

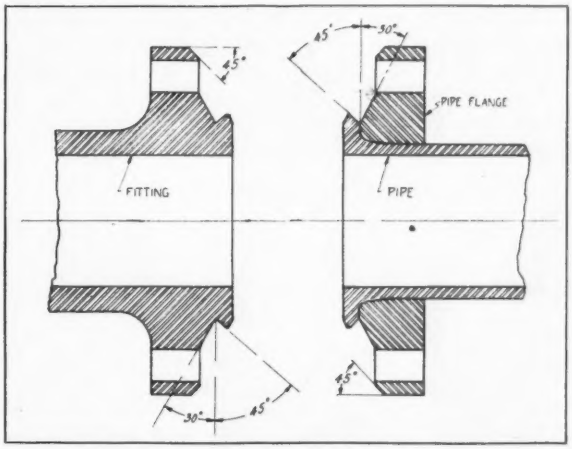


FIG. 2. THE SARGOL JOINT IS MADE UP WITHOUT A GASKET

NO GASKETS USED IN JOINTS

IT SEEMS to be an established fact that the Sargol welded joint is the best joint so far developed for high pressure work. This joint is made as shown in Fig. 2. The pipe end is upset similar to the VanStone joint, but is specially machined for welding while the fittings have a special face as shown. No gaskets are used, the weld being used to seal the joint while all of the stress is taken by the bolts and not on the weld. In putting up this joint, temporary bolts are used while the welding is being done which bolts are replaced when the weld is completed. In one plant where a large number of these joints were used on 350 lb. piping, there has not been a joint leak in over two years of service.

The foregoing applies only to steam lines as it is thought the ordinary raised face joint, similar to the A. S. M. E. hydraulic standard, or the tongue and groove flange joint is satisfactory for water lines, such as blowoff and boiler feed lines.

Steel and monel still seem to be the best materials for valve construction so far developed, and all bronze should be eliminated where it is subjected to high tem-

peratures. Forged steel is much better than cast steel, due to uniformity of the metal and greater strength at the higher temperatures but on account of manufacturing difficulties these can be made only in sizes up to 2 or 2½ in. The writer believes that screwed and forged steel valves are suitable up to 1½-in. size for pressure of 350 lb. and up to 1 in. for 500 lb. Above these pressures, they should be flanged and preferably have the Sargol welded flange. In the design of valves the same general rule, that is, a factor of safety of 4 on the elastic limit at the temperature used, should be employed.

There is no greater tendency for high pressure steam to wire draw and cut the seats and discs than for lower pressures, the cutting action depending on the velocity and particularly on the amount of moisture in the steam. There is very small tendency for a perfect gas, free of moisture, to cut. The cutting is caused by small particles of moisture blown against the seating faces at high velocity. Thus no particular trouble is expected from valves handling dry or superheated steam such as non-return valves, header stop valves, etc. For

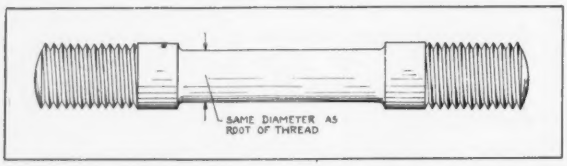


FIG. 3. SPECIAL STUD BOLT FOR USE ON HIGH PRESSURE STEAM LINES

such valves as blowoff valves, drips and drains, where the pressure is released to atmospheric pressure, the velocity will naturally be higher, moisture and solid water will be present and naturally the cutting of the seats and discs will be greater. Such lines should have two valves in series, one of which will be used as a stop valve only and be opened before blowing, the other used as the operating valve.

Emergency Operating of Stop Valve

Due to the higher cost and larger size of the generating and boiler units and the greater damage which would be caused by a header rupture, a number of engineers are specifying emergency operation of the boiler non-return valves and the header sectionalizing valves. This may be by means of a steam closing cylinder attached to the valve spindle, operated by means of a solenoid trip, which exhausts the steam under a piston allowing the pressure above the piston to close the valve; or, the valve may be motor operated and equipped with one of the several motor operating devices now on the market. In such cases, the valve is equipped for opening and closing at the boiler and there are usually provided at least one or more emergency closing stations. These emergency stations should control by one button all the valves on one unit, that is, all the boiler non-return valves and the header sectionalizing valves. Emergency stations are usually placed in one or more of the following places: boiler room, superintendent's office, turbine room and switchboard gallery.

Using the ordinary cold rolled steel, the strength of which decreases rapidly with increase of temperature above 500 deg., it is practically impossible to get in enough bolts to give the required factor of safety. This has led to the use of special alloy steels, usually a chrome-nickel alloy, having a higher tensile strength and less affected by temperature. Some of this material has a tensile strength of well above 100,000 lb. per sq. in. with an elastic limit of over 75,000 lb. per sq. in. All bolting should be done with double ended studs instead of bolts on account of the crystallizing effect of the upsetting process on the bolt head. On account of the pipe stresses, which cannot be calculated, the bolt stress calculated at the root of the thread, and figured at the outside diameter of the gasket or welded joint should not exceed 5000 to 6000 lb. per sq. in. For the bonnet bolting, due to absence of pipe stress, the stress may be increased to 8000 or 9000 lb. per sq. in.

Due to the fact that in the ordinary stud the tendency is for all the elongation to take place at the root of the threads not engaged in the nut, where the diameter is the smallest, a special stud will probably be used to distribute this elongation over a greater length. A sketch of this stud is shown in Fig. 3.

Flange Dimensions

Considerable confusion has resulted from the lack of an A. S. M. E. standard for these higher pressures. Special flanges and drilling have been worked out for each job by the engineers. The most usual standard has been the A. S. M. E. 800 lb. hydraulic for pressures up to 400 or 450 lb. and the 1200 lb. A. S. M. E. hydraulic for higher pressures. This condition increases the cost of manufacture due to the number of special patterns, jigs and fixtures required and also prevents interchangeability of parts.

The American Society of Mechanical Engineers, as well as a number of manufacturers, have done considerable work on flange standardization for the higher pressures but nothing has been adapted as standard. It is believed that two standards as far as bolt circle and number of bolts are sufficient for all pressures up to 1200 lb., but that the flange diameter, flange thickness and size of bolts should be increased and standards established for 400, 500, 600, 800, 1000 and 1200 lb.

It is believed that the present American standard for extra-heavy drilling should be extended up to and including 500 lb. as far as drilling circle and number of bolts are concerned, but that the flange diameter and thickness and size of bolts, be calculated scientifically to withstand the various working pressures with a satisfactory factor of safety; and that this standard for flanges be known as the American Extra Heavy Standard, as heretofore, except that the pressures be designated in connection with it.

It is further believed that the present 1200 lb. Hydraulic Standard should be adopted for pressures ranging above 500 lb. to 1200 lb., inclusive, and that the drilling circle and number of bolts should be calculated scientifically to provide for a satisfactory factor of safety under various pressures above 500 lb. to 1200 lb., inclusive, and that this standard be called the American Double Extra Heavy Standard with pressures designated.

The writer has endeavored to give a general outline of the problems involved, and the best current practice in high pressure piping work and, no doubt, the near future will show some very interesting developments with reference to alloy cast steels for high temperatures.

Care and Operation of Fuel Economizers

ECONOMIZERS, LIKE BOILERS, NEED ATTENTION, AND WHEN THIS ATTENTION IS GIVEN THEM, THEIR OPERATION WILL BE ENTIRELY SATISFACTORY. BY H. M. GUILBERT*

IN VIEW of the fact that fuel economizers form an auxiliary to a boiler installation, it is only natural to expect that the questions which come up in connection with their use will be similar to those met with in boiler operation and, with certain exceptions, resulting from the different operating conditions, this proves to be the case.

In considering the important points in operating economizers so as to obtain the greatest return and the most satisfactory service, it will be worth while to discuss for a moment the problems brought out by their use. First and foremost among them is the question of corrosion. It has been found by experience that feed water entering an economizer at a temperature much below 100 deg. F. causes the tubes to sweat. If the fuel is such that the flue gases are free from sulphur, as when hogged fuel is being burned, no harm will result from this condition; but as the gases from coal and oil invariably contain a certain amount of sulphur, the average installation is liable to be affected if the condition of moisture on the tubes is not remedied. The sulphur content of the flue gases, uniting with this moisture, produces an acid solution which eats into the metal and will eventually result in the formation of a hole. Through this hole the water within the tube will be sprayed over the adjacent tubes, producing corrosion on a large scale.

It is obvious that the simplest remedy for this condition, inasmuch as it is ordinarily impossible to remove the sulphur content of the flue gases, is to raise the temperature of the feed water to a point at which no sweating takes place. Usually this is done in feed water heaters, using exhaust steam. Where there are no facilities for this, it is a simple matter to run a line of ¾-in. pipe from the hot end of the economizer to the cold end, thus recirculating part of the heated water and so bringing the temperature of the water up to the desired point. This to some extent reduced the immediate return; but the economizer lasts longer, so that this loss is more than counterbalanced by the ultimate gain.

Interior Corrosion

INTERNAL CORROSION is produced by the oxygen contained in the water, which is driven out of solution by the increase in temperature, unless the vapor tension is such that this result cannot follow. In economizers with cast iron tubes the action of this corrosion is almost negligible, although it is true that, together with the natural wearing effect of erosion, it is the chief determining factor in the life of the machine. Theoretically, if conditions were such that neither could take place, economizers would last indefinitely, actually their average life is in the neighborhood of 15 yr. It is evident that the question of both internal and external corrosion becomes much more serious when the tubes of an economizer are made of steel, and even with cast-iron tubes there have been instances in which, over a period of 7 yr. corrosion has involved replacing 25 per cent of the original material, owing to a condition of unusually high sulphur content in the coal.

Steel Tube Economizers

THE PRESENT trend toward higher boiler pressures has brought the subject of economizers with steel tubes into increasing prominence, and at least three such machines are now on the market. Two of these depend

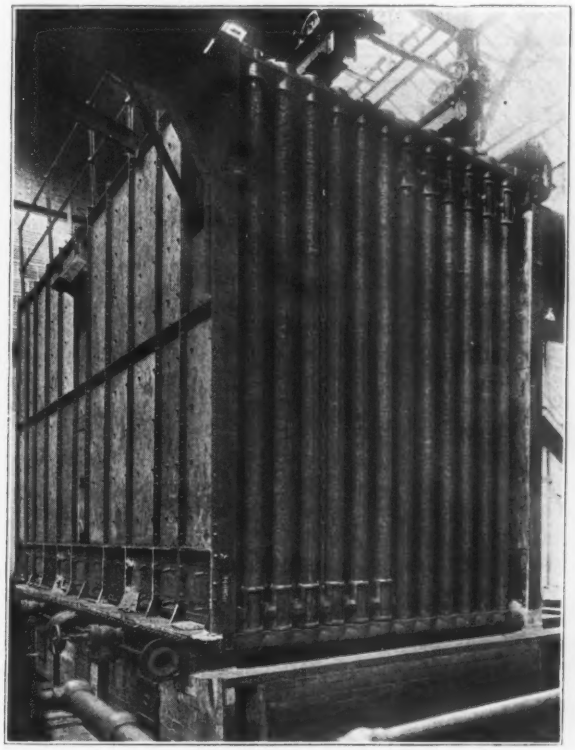


FIG. 1. A CAST-IRON ECONOMIZER INSTALLED AT THE "L" STREET STATION OF THE EDISON ELECTRIC ILLUMINATING COMPANY AT BOSTON

for the protection of the tubes against inside corrosion upon the use of deaerators, of which there are two types in general use. In one the dissolved oxygen is removed from the water by boiling it at less than atmospheric pressure; in the other the water is brought into contact with iron plates, and the oxygen is removed by the rusting or oxidation of these plates. This type of apparatus is necessary if advantage is to be taken of the economy to be gained by a low entering temperature, as raising the temperature of the entering water to 214 deg. or higher naturally involves a loss in the return from the economizer itself unless bleeding of steam from turbines is resorted to. In the third of the steel tube economizers to which reference has been made, protection against outside as well as inside corrosion is obtained by means of a lead coating on both the inner and outer surfaces of the tubes, for which a life of many years is between the bottom headers and the side walls, or in the

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claimed. Not only is this protection obtained through the chemical stability of the lead alloy, but the resulting surface is one to which soot, scale, and the minute particles of dissolved oxygen adhere with greater difficulty.

Removal of soot from the outside of the tubes is of greater importance than is generally realized, as it has been estimated that ¼ in. of soot or of scale reduces the efficiency of the machine by 10 per cent. The question of scrapers versus soot blowers is today a particularly live one, and as usual in such arguments, there is much to be said on both sides. Both methods of removing the soot are open to objections, and each, in the nature of things, sometimes involves unwelcome expense. Owing to the fact that so many users of economizers fail to insist that proper care be given to the scrapers, three-fourths of the troubles with economizers may be traced to this cause. The sure way to prevent this is to see that a trustworthy employe is instructed to inspect the operation of the scrapers at frequent intervals, and to keep the gearing properly lubricated, a point to which special attention should be paid on account of the temperature and dryness of the air above the economizer.

Soot blowers are in use in many installations with satisfactory results. While the initial cost is practically the same, they require less attention, with consequently less exposure of the economizer attendant to the heat around the machine, and by removing the necessity for chain holes, reduce the leakage into the economizer. Scrapers, however, operate dry and have the advantage of depositing the soot in hoppers underneath the economizer, while soot blowers shoot it into the stack and also deposit a certain amount of moisture on the tubes. This is of small importance where the water entering the economizer is well above the dewpoint of sulphuric acid. There is always the possibility of saturating the particles of soot on the tubes so that corrosion sets in. In connection with soot blowers, it should be noted that if they are operated with superheated steam and the installation is such that the tubes are exposed directly to the continuous action of the jets, rapid and disastrous erosion is apt to result from the blow-pipe effect so produced.

Scrapers if properly operated and soot blowers when used under the correct conditions, will remove the ordinary deposit of soot. If for any reason the tubes become heavily coated with soot, the scraper chain sheaves may be disconnected and the scrapers operated independently by hand. If this fails, the accumulation may be removed by burning it off, but this process should be resorted to as infrequently as possible, and on no account should it be done if there is any deposit or incrustation on the interior of the tubes.

In burning off the soot the procedure is as follows: a wood fire is built in the soot-pit under the economizer from one end to the other, the water having first been entirely drained off. Care should be taken to open all vent cocks and remove a few of the top caps so that if enough water has remained in the economizer to form steam no undue pressure will result. The fire should be kept going for a day and a night, or for two days if it is impracticable to continue it during the night, with the scrapers operating continuously throughout this time. By the end of this period the carbon deposit should be thoroughly loosened so that the scrapers will remove it. Emphasis should be laid upon the fact that this procedure is rather a delicate one and that it should preferably be carried out under the supervision of an experienced operator in order that no overheating and unequal expansion will occur.

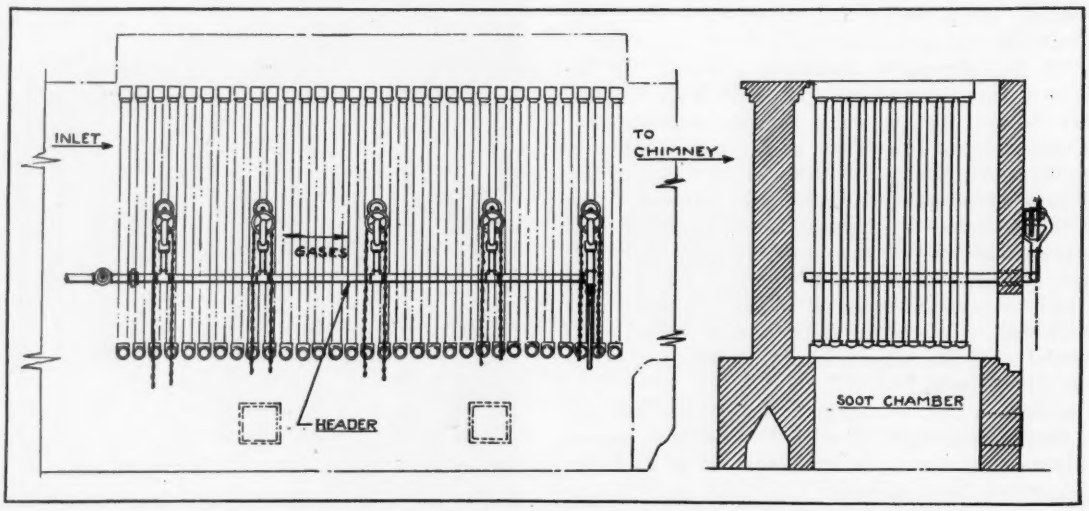


FIG. 2. TYPICAL SOOT BLOWER ARRANGEMENT INSTALLED ON STEEL TUBE ECONOMIZERS

If economizers are washed down with a hose, serious damage may result from these different sources. The water will be absorbed by the particles of soot adhering to the tubes, and when the gases are again turned into the economizer, corrosion will start, the action of which will be concentrated around the particles of soot. The brickwork and masonry in the setting will be injured not only by the washing action of the water, but by the expansion effect of the steam produced from the contact between the hot gases and the wet brickwork. A brick will absorb 50 per cent of its weight in water, and the loosening of the setting may become a serious source of leakage of air into the economizer chamber. Finally the steam produced will have a general corrosive effect in addition to the one mentioned.

One point to which too little attention is paid is that soot should not be allowed to accumulate in the spaces

soot pit. A regular routine for the removal of these accumulations should be insisted upon.

The question of scale in the tubes is not so serious as might at first be expected. As the temperature of the water in an economizer is ordinarily not higher than 250 deg. F., the hard sulphates of lime, which cause so much trouble in the tubes of a boiler, are not precipitated out, and the only scale-forming elements to be taken into account are the bicarbonates of lime and magnesium. These form a sludge which in most cases can be washed out with a hose, and in the unusual instances in which hard scale has formed, a water-driven rotary tube cleaner, of which there is on the market a type especially designed for use in economizer tubes, will be found particularly effective. The water both acts as a cushion between the implement and the tube and serves to flush out the scale as it is loosened and displaced.

Prevention of Corrosion

Economizer tubes, to obtain the best results, should be kept as thoroughly cleaned as boiler tubes. Feed water having any detrimental effect should be treated, and if necessary to offset the action of bad feed water the tubes may be coated internally. A special filler is obtainable for this purpose at a low cost. It is boiled in a tank, usually by means of a steam line, and then allowed to flow into the economizer until it is full, care being taken to see that the mixture is thin enough to flow properly through the entire machine. The flue dampers are then partly opened until the liquid boils again, with the vent cocks open to permit the escape of the steam. This filler gives the tubes a smooth protective coating which resists the corrosive action of the water and makes more difficult the formation of any deposit of scale. A protective paint is also on the market which produces a smooth coating on the inside of the tube with similar results.

Some Points on Operation

Perhaps the respect in which practical operating conditions differ most widely from the theoretical is in the leakage into the flue. In many installations, a perceptible improvement would result from a careful inspection of the flue work and the remedying of any settling, loosening of the mortar, or other conditions which allow air to leak in and thus lower the temperature of the gases as they pass through. This inspection should include the dampers of boilers out of service if there are any, as there is often a serious leakage from this source. Careful readings of the temperature and the CO_2 should be taken periodically at the inlet and outlet of the economizer. The draft should be regulated by automatic dampers at the stack uptake or the economizer outlet and not by the dampers at the boiler uptakes or the economizer inlet. There is usually so much infiltration of air into the flues and through the economizer setting that in figuring the induced draft fans an allowance must be made for leakage, varying from 5 or 10 per cent under average conditions to 50 per cent in the case of a waste heat boiler.

Economizers should be blown off as frequently as it has been found necessary to blow off the boilers, depending upon local conditions. Usually this means for a few minutes every day, and it should be done by means of both the relief and the blowoff valves. The interior of the tubes and headers should be carefully inspected at least once a year and thoroughly cleaned if it is found necessary. The relief valves should be tried out at least daily, and the seats should be reground at the first sign of wear. In no case should the relief valves be plugged, nor should the pressure at which they release be increased above that at which they are set, as this setting is done by the economizer manufacturer and often is close to the working pressure for which the economizer is designed.

It is always preferable to put an economizer into service at the same time the boiler is started, rather than to cut it into service while the boilers are carrying a load. It is obvious that the warming-up and expansion are much more gradual under the former conditions and the more often the pipes are cooled and heated, the more corrosion will take place. The economizer should always be cold before any water is allowed to enter it and before it is cut into service it should be completely filled, making sure that there are no air pockets. Safety air cocks are provided to vent the air during the filling process. In starting the gas through the economizer, the inlet and outlet dampers should be opened gradually, leaving the bypass dampers wide open until the other dampers have been opened full and the economizer has been thoroughly warmed.

The scraper mechanism should be operated continuously while gases are passing through the economizer. In installations equipped with soot blowers, experience, aided by temperature readings, will indicate the intervals at which the soot should be blown off. Scraper chains should be kept free from grease, and no oil should be used on the chain sheaves, while only a small quantity is required on the chain sheave bearings. The driving head should be carefully and thoroughly lubricated. Each chain sheave may be disconnected from the rest of the scraper mechanism by removing the connecting bolt, and the scrapers may in this way be adjusted separately. If the chains stretch they should be shortened so that the scrapers travel exactly the full length of the tubes.

In removing the economizer from service, the more gradually it is done, the better. The first action, of course, is gradually to stop the passage of the hot gases through the economizer chamber. When this has been accomplished and while the water is still passing through it to the boilers, the relief valves can be opened gradually. When there is no longer any pressure in the economizer, and it is desired to drain it, the blowoff valves may be opened. It is important that the sequence of operations be as follows: First open the bypass dampers, then close the economizer inlet damper. Next open the valve of the feed water bypass to the boiler and close the feed valve to the economizer. Then the soot-pit doors and the vent doors in the sectional covers should be opened, and after the fresh air has been allowed sufficient time thoroughly to scavenge the gases from the economizer, the outlet dampers should be closed. The soot pit doors, rear damper cover plates, and sectional cover vent doors should be left open while the economizer is out of service.

If it is out of commission because of boiler failure, the outlet valve should be closed and the relief valves opened. If this is done, there is no objection to leaving the water in the economizer provided the water is not under pressure.

Some Turbine Disorders

WARNING SO SLIGHT AS HARDLY TO MAY BE CAUSED BY SUCH CONDITIONS

IN ONE of the plants under the writer's observation, it was the practice to keep what was called a "defect sheet" on which any out-of-ordinary conditions of the units were noted; viz., "Operating engineers reported No. 1 turbo-unit not responding to swinging overloads of about 10 per cent, and also slowing down with normal rated load on." Inspection showed the high pressure blading to be practically stopped up with scale deposit. This condition was corrected by proper treatment and filtration of feed water.

Boiler water supply was taken directly into the feed water heater without sedimentation or filtration from a river containing bad scale forming salts. Boilers foamed and primed badly under load conditions that had to be met; accordingly, deposits were carried over and left in pipe lines, traps and separators.

Figures 2, 3, and 4 show up the effects of "wet steam" supplied to turbines. In Fig. 2 the erosive action of the moisture has seriously eaten into the cast-iron cylinder wall between the rows of blading and you will note the roots of the blading entirely exposed in some cases. It was necessary in this instance to insert pieces of bronze metal between the blading in order to keep the machine in service. These

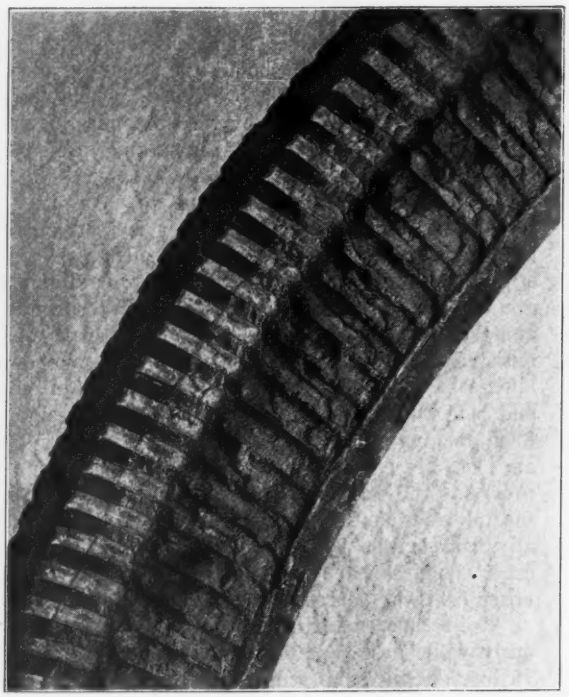


Fig. 1. Responsibility for this stone inlaid disk is attributed to the boiler water.

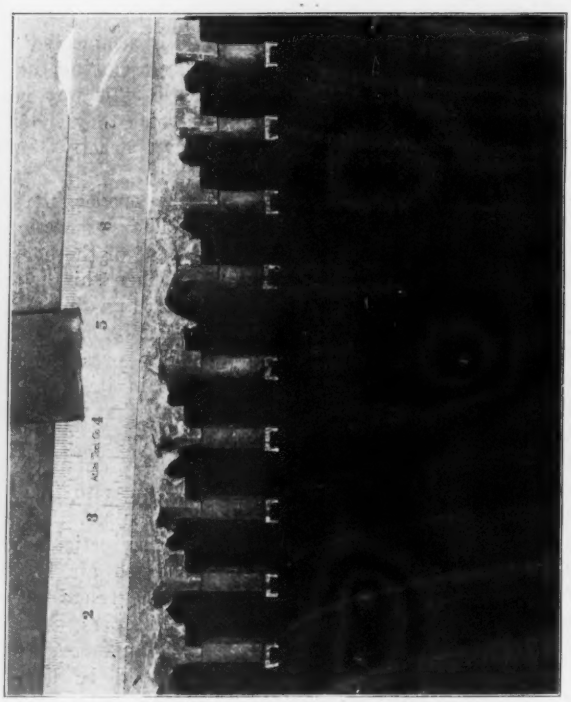


Fig. 2. Moisture in the steam has seriously weakened blading by cutting metal away from the roots.

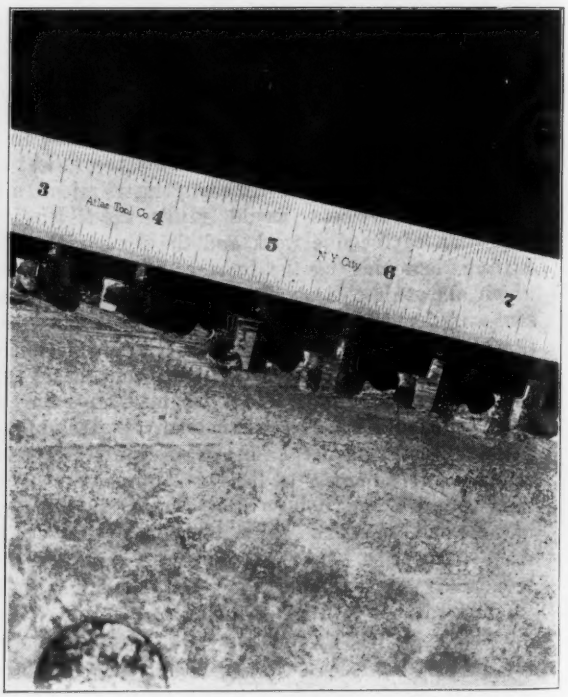


Fig. 3. The erosive effect of water in the steam is clearly shown in this picture.

Revealed By Inspection

BE NOTICED EVEN BY SKILLED OPERATIVES AS ARE SHOWN HERE. BY GUY S. WARDEN*

pieces were fastened with counter-sunk screws into the cylinder wall, and to the best of the writer's knowledge the unit is still running, but with an appreciably higher steam rate. Figures 3 and 4 show further details on this same unit, Fig. 4 is a view looking between the row of blading from the top and shows the wavy action of the water in its travels through the machine.

Figure 5 is a view of a rotor and clearly indicates that something had been rubbing the blading quite severely, yet the machine did not indicate any signs of such internal condition which was discovered when the unit was opened up for regular inspection. One row of blading was loose in the cylinder and one end sprung enough to cause the rubbing. Erosion of the steel shaft between stages is also evident.

On placing a turbo-unit on the line in a hurry one morning the watch engineer reported that the machine had made quite a noise, but had steadied down and was running normally. As the unit was due for inspection in the next four weeks, it was decided to let it stay on. When inspection time came around, the unit was opened up and four rows of blading were found as shown in Fig. 6.

*Power Engineer, E. I. duPont de Nemours & Co.

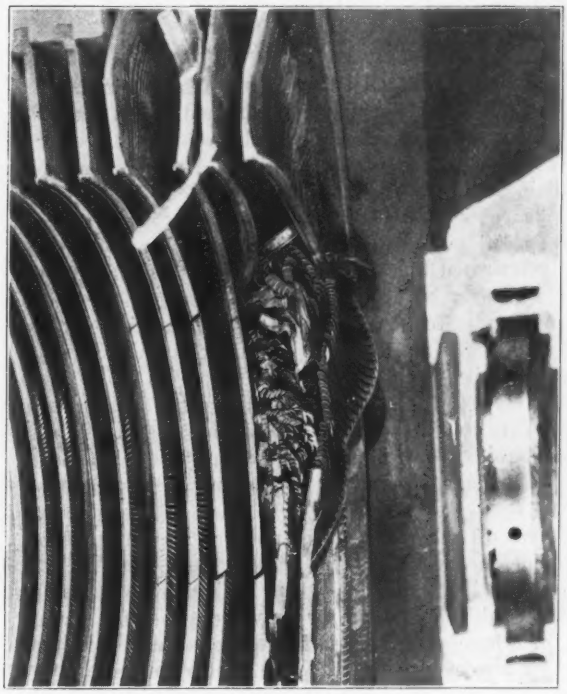


Fig. 6. Evidence shows turbine ran in this condition for several weeks.

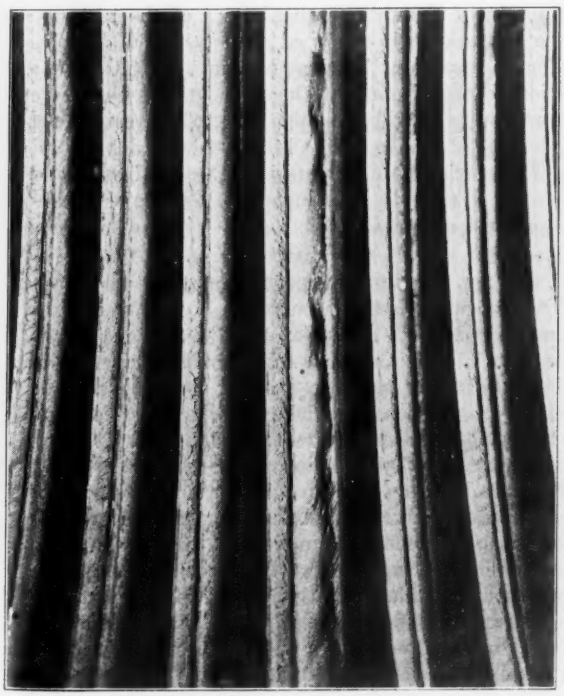


Fig. 4. Looking down between the rows of blading the wavy action of the water is discernible.

Fig. 5. Rubbing evidently took place here and the steel shaft is severely eroded.

Electrically Operated Valves

USE OF MOTOR OPERATED VALVES IS RAPIDLY INCREASING. BY FRANK D. RHAME*

ELECTRICALLY OPERATED valves are finding a constantly growing field of application. In addition to the initial installations of these valves in power plants for such purposes as boiler lead controls, for sectionalizing, and for turbine lead valves, electrical operation has now been successfully applied to valves for other special purposes. The practicability of an electrically operated non-return boiler stop valve has been definitely determined and for the automatic maintenance of a pressure differential between two connected headers receiving steam at different pressures, an electrically operated globe valve actuated by a special "U" tube device, appears to possess certain distinct advantages. Additional applications for the advantageous use of valves of this type will, no doubt, be found as the marked utility of electrical valve control becomes more generally known.

Valves of either the globe type or gate pattern are adaptable to the use of electrical control—the use of this control being ordinarily specified for valves which are not readily accessible for convenient manual operation, or where positive, quick closing is desired in the event of an emergency. To fulfill the requirements of these operating conditions which necessarily demand absolute reliability of operation, ease of action and freedom from wear or increasing friction as the valve continues in service, there are certain factors of design and features of construction which are now considered as essential details of valves equipped with electrical control.

As in all valve construction, but especially so in electrically operated valves, the accessibility of all parts is a vital consideration. The use of a "unit" control for valves of this type is extremely desirable, in that the operating mechanism is distinctly made as a separate unit, easily detachable for examination or repair. In like manner, the general construction of these valves should permit the easy renewal of parts subject to wear. The yoke, or arch members which support the motor and gearing, should be of adequate strength to provide the required rigidity and to prevent undue vibration, as any distortion may result in misalinement of the valve stem, with possible binding and excess wear of moving parts.

To compensate for the thrust on closing, the yoke nut or bushing on electrically operated valves should be provided with a ball thrust bearing. This ball bearing reduces the operating friction and eliminates the possibility of a noisy worn bearing developing at this point. By reason of the thrust and transmission of power through it, the yoke bushing should be of heavy proportions to provide excess strength. Monel metal, with its high tensile strength and resistance to corrosion, is used to advantage in this part.

Materials used in the parts bearing upon the stem of an electrically operated valve must be so selected as to offset any tendency to promote corrosion or pitting. Rod monel is commonly used for stems of these valves and bronze or monel metal "liners" are inserted at the stem bearings in the stuffing-box and valve bonnet. This practice provides materials which will render maximum service without danger of corrosion and possible increase of friction.

Discs of valves of the globe type are usually mounted in such fashion that freedom of valve action is not questioned. In gate valves, however, it is highly desirable to provide positive means of preventing the "dragging" of the disc across the seating surfaces during the operation of the valve. The occurrence of any such "dragging" action will not only produce useless continual wear of the seating surfaces but will also cause other undesirable frictional resistance. As electrically operated gate valves are generally intended to close under emergency conditions when such "dragging" would be particularly objectionable, it is especially important that such valves be equipped with solid discs provided with machined guides which bear upon machined internal body ribs, thereby definitely controlling the freedom of the valve disc and limiting any undue "play" in its movement. With this construction, the disc comes into contact with the seat only just prior to the complete closure of the valve. In addition to the use of machined disc guides, the edges of the discs of electrically operated gate valves should be rounded to prevent any cutting or scoring of the seat as the valve closes.

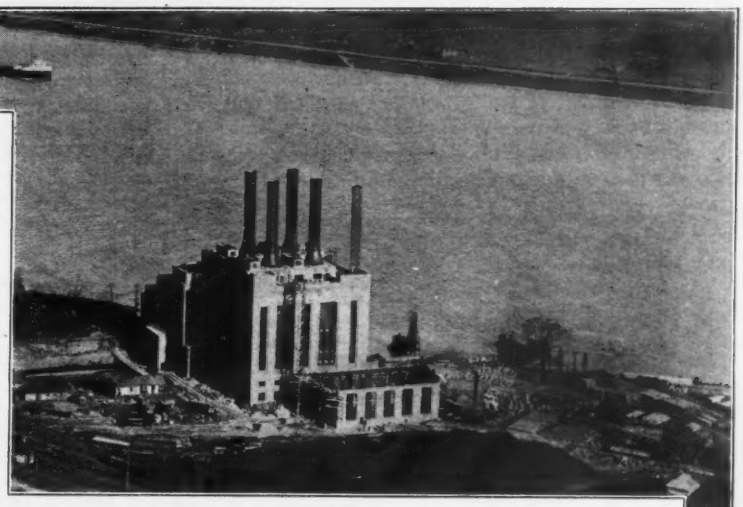
Electrically operated valves should be provided with a handwheel to permit manual operation, when that is desired. With the handwheel mounted directly upon the yoke nut, the use of a "declutching device" permits the operation of the valve by hand without involving the rotation of the gear mechanism or of the motor.

The motor unit is equipped with means of lubrication for its important bearings and to permit the same attention to the bearing of the yoke nut on the valve a grease cup is provided on the yoke. The valve stem, being exposed, can be easily lubricated by a hand oil can. The gearing on electrically operated valves should be covered, to provide cleanliness and to serve as a safeguard against accident.

U. S. CIVIL SERVICE COMMISSION announces an examination for apprentice draftsman to fill vacancies in the office of the Chief of Ordnance, War Department, Washington, D. C., at an entrance salary of $600 a yr., plus the increase of $20 a month granted by Congress, and vacancies in positions requiring similar qualifications. The receipt of applications will close on June 19. Applicants must have had training and actual experience in mechanical drafting, obtained either in the drafting room of a manufacturing establishment or a Government establishment, in the drafting classes of day or night schools, or in drafting courses of correspondence schools. They must be familiar with the use of drawing materials and instruments and the equipment of a mechanical drafting room. Competitors will not be required to report for examination at any place, but will be rated on their education, training, and experience, and practical tests. Full information and application blanks may be obtained from the U. S. Civil Service Commission, Washington, D. C., or the secretary of the Board of U. S. Civil Services Examiners at the post office or customhouse in any city.

*Sales Engineer, The Lunkenheimer Co.

New Marysville Plant Handles Increasing Demand



TWO UNITS AT THE NEW DETROIT EDISON PLANT ARE SUPPLIED BY FOUR 2821-HP. BOILERS. BY PAUL W. THOMPSON*

DEMAND FOR electric energy in the vicinity of Port Huron has increased to such an extent as to make the provision of a generating station to serve this district advisable. Consequently the Marysville plant was constructed on the St. Clair River just north of Marysville and 5 mi. south of Port Huron. This plant will supply the demand of the northern and northeastern section of the territory served by The Detroit Edison Co. and will be tied into the main distribution system which is spread over a semicircular area of about 60 mi. radius with the city of Detroit at the center.

The Marysville plant is designed for an ultimate capacity of 140,000 kw. The plant already constructed contains 40,000 kw. generating capacity—one 10,000-kw. unit and one 30,000-kw. unit, with space for a third 10,000-kw. unit. These turbo-generators are served by four 2821-hp. boilers which are sufficient for serving the full 50,000-kw. generating capacity.

General arrangement of the plant is shown in Fig. 2 and in cross section in Fig. 1. The building straddles the bed of a creek and is so constructed that the turbine room is directly above the creek bed, with the boiler house on one side and the switch house on the other. This method of construction was employed so that the tendency of the foundation to slip upon the supporting clay would be reduced to a minimum. The intake and discharge water canals pass under the condenser room as well as the canal, which is constructed to carry the normal flow of the creek. Arrangements are made so that in case of abnormally high flow of the creek, part of the water can overflow into the discharge water canal.

COAL HANDLING

AT THE present time, all coal is received by rail; but the construction of a dock would permit receiving coal by boat. The coal is unloaded from cars into the two receiving pits, which are located below grade in the coal house adjacent to the south end of the boiler house. It is then conveyed by either one or both of two inclined steel pan conveyors to the two crushers, located in the boiler house at grade, which crush the coal to a size not greater than 1¾ in. From the crushers, it drops into bucket conveyors which elevate the coal to the bunker room floor where it is either dropped into the bunkers, directly under the conveyors, or carried by three distributing belts, running in a line perpendicular to the travel of the bucket conveyor, to the other bunkers. The entire coal handling equipment will handle 280 T. per hr.

BOILER ROOM

BOILERS ARE of the class "W" Stirling type, as shown in Fig. 3, 53 tubes wide, having 28,212 sq. ft. of effective heating surface and 3168.6 sq. ft. of superheater surface each. They are designed to supply steam at 275 lb. gage pressure and 700 deg. F. temperature at a maximum rating of 300 per cent. All boiler auxiliaries are designed for 300 per cent maximum rating of the boiler. This type of boiler as heretofore installed has been 13 tubes deep in each half with seven rows of tubes in each first bank and six in each second or back bank, and baffled to give two complete passes to the gas. From the results of tests conducted by the writer during the summer of 1921 on a type "W" Stirling boiler at the Connors Creek plant,† certain changes in the design were found advisable and were embodied in the design of the Marysville boilers. The principal change was a reduction of the number of tubes in the first bank from 7 to 5 and an increase of the number in the back bank from 6 to 10 for each half, making this boiler as a whole 4 tubes wider than the old boiler of the same type. Increasing the number of tubes in the back bank made it possible to increase the total number of gas passes from two to four, resulting in a marked reduction in temperature of gases leaving the boiler with a corresponding increase in efficiency.

Each boiler is fired by two three-ram Taylor under-

* Technical engineer of power plants, The Detroit Edison Co.

†Paper presented at the 1922 Annual Meeting of the A. S. M. E., Test of Type W Stirling Boiler, etc.

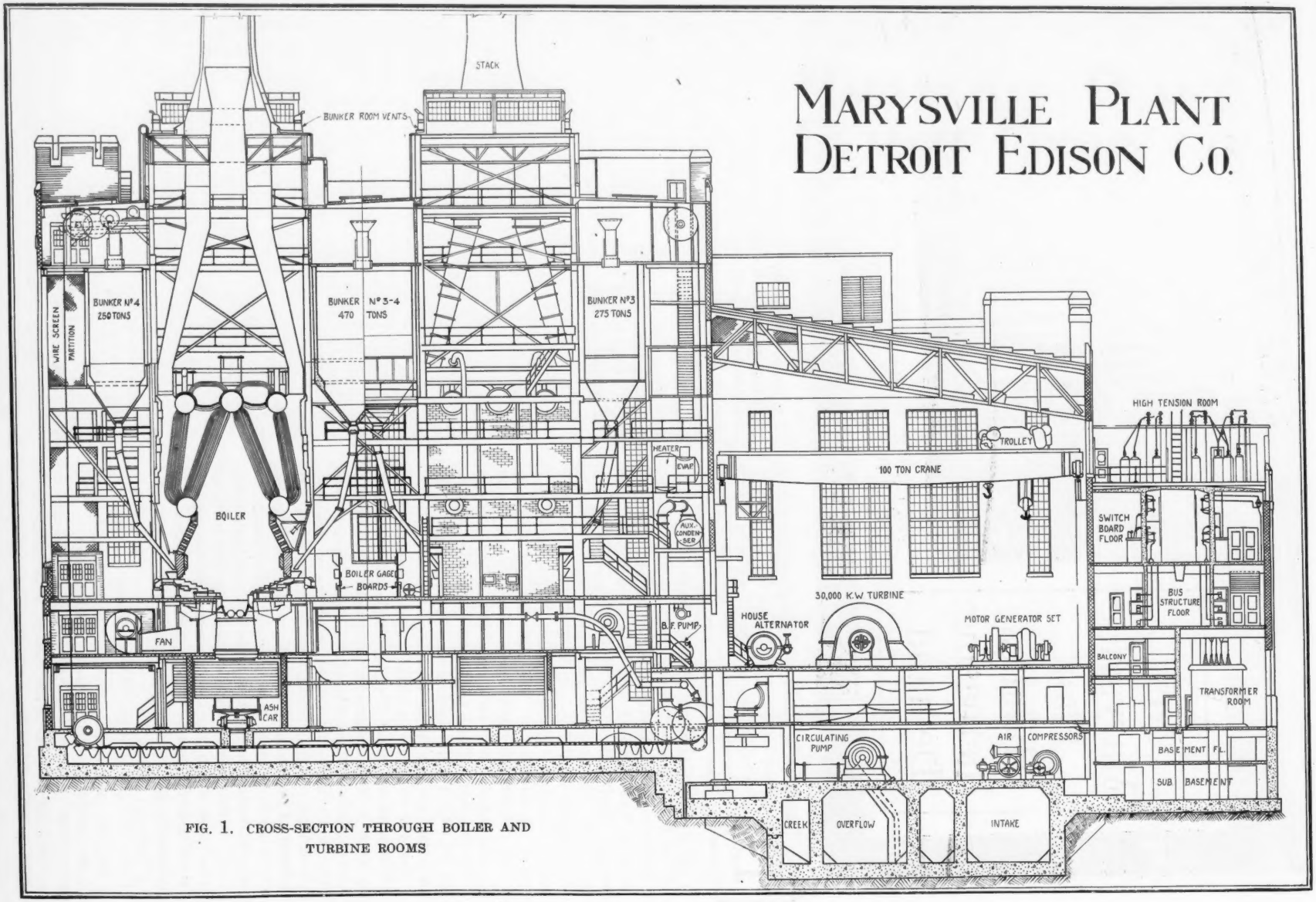


FIG. 1. CROSS-SECTION THROUGH BOILER AND TURBINE ROOMS

feed stokers each having 14 retorts. The projected area of the two stokers, exclusive of extension grates and ash pit, is 392.1 sq. ft. Each tuyere stack contains 22 tuyeres. The extension grates have small openings in them which permit a small amount of air to penetrate the ash, reducing the carbon content to a minimum. At the bottom of the stoker ash pit is a two-roll clinker grinder, each roll turning over towards its respective

capacity of 103,000 cu. ft. of air per minute at 7.25 in. of water static pressure. Between each pair of boilers there is a spare blower which will supply air to either, but not both boilers at once. The blowers receive their air from the pipe gallery. This air is warmed up by radiation from the main and auxiliary steam piping. Air used for cooling the main generators is also discharged into the pipe gallery and mixes with the other

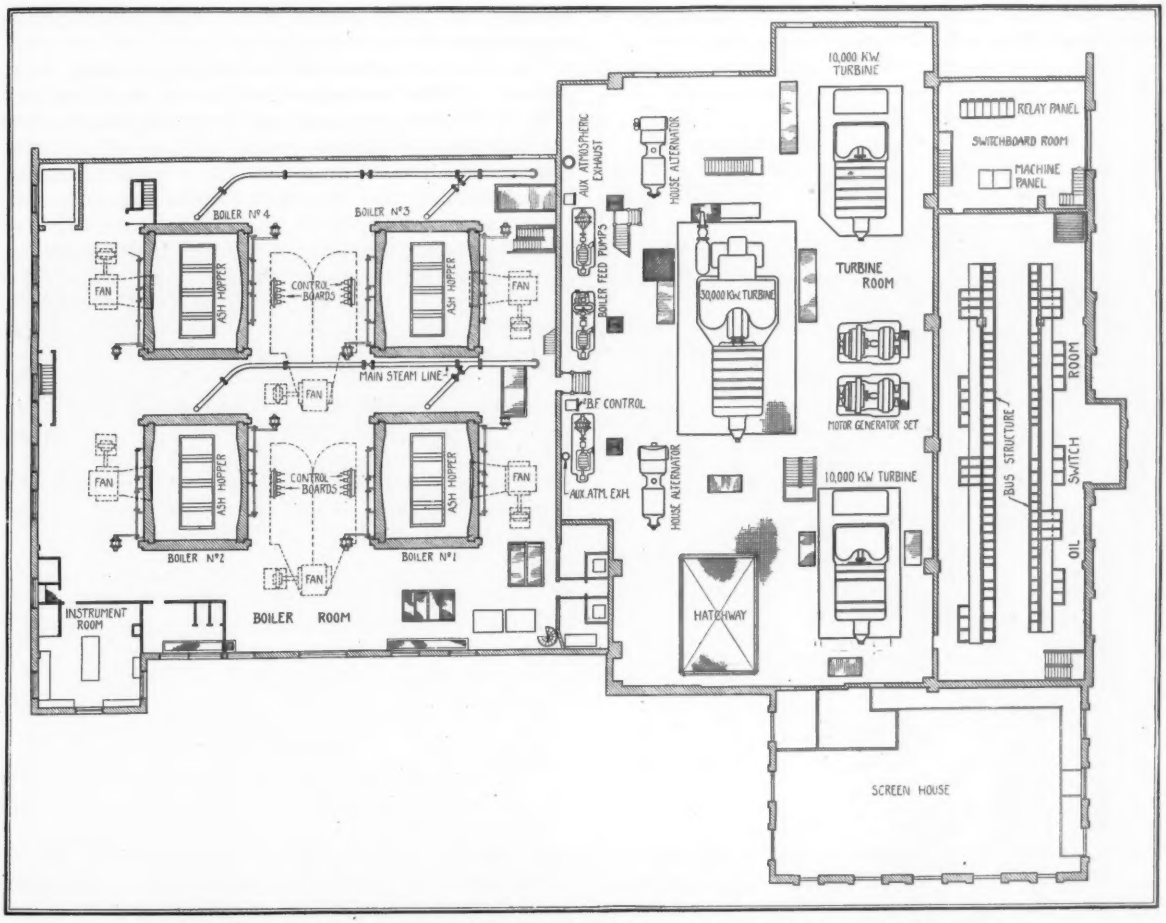


FIG. 2. PLAN OF PLANT SHOWING LOCATION OF BOILERS AND GENERATING UNITS

adjustable apron. Each stoker is driven by an adjustable speed 220-v. d.c. motor having a speed range of 4 to 1, the controls for which are on the respective boiler instrument and control boards located in the center boiler room aisle. Figure 4 shows the boiler room operating floor and the location of the instrument boards. The power boxes are of a recently developed type having two speeds, which is found to increase the flexibility of operation. By throwing a switch on the control board, the stoker motors can be thrown onto the 110-v. service line, which greatly increases the total available speed range. This reduced speed is required during low ratings or periods of banking where a steady low rate of feed is required. The clinker grinders are each separately driven by adjustable speed d.c. motors which are interchangeable with the stoker motors. Further flexibility of control is obtained by adjusting the ratchet drive on the rolls.

The two stokers under each boiler are supplied with air from an individual forced draft blower having a air giving a higher temperature than would otherwise be obtained. Each blower discharges into its plenum chamber which encloses the space between the boiler room floor and the pipe gallery floor directly under the boiler which the blower is serving. The ash hopper which passes through the plenum chamber has an inspection door in each end so that the operator, by entering the plenum chamber through the air lock, may inspect the clinker grinders at regular intervals.

Firebrick is used exclusively in the construction of the furnace which is 19 ft. 4½ in. by 26 ft. 7 in. between walls. The boiler is hung from a steel framework between the four boiler columns so constructed as not to interfere with the two boiler breechings. The mud drum is 18 ft. 9 in. above the operating floor and the steam drum 39 ft. 9 in. This gives a total furnace volume of approximately 9727 cu. ft. Since the first installation of this type of boiler at the Delray plant in 1911, the tendency has been to increase the height between the stoker and the boiler. Although all of this

type boilers at Delray were set at an equal height, the boilers at Connors Creek were set with the mud drum 15 ft. 9 in. above the operating floor which was 3 ft. higher than the Delray boilers. The increased height gave a better combustion volume in the furnace with resulting better combustion conditions. At the Marysville plant, it was believed that combustion would be enhanced by a still greater combustion volume, hence the higher setting of the boilers. The inclined wall just below each mud drum is built of special tile supported with clamps from a framework of angle iron.

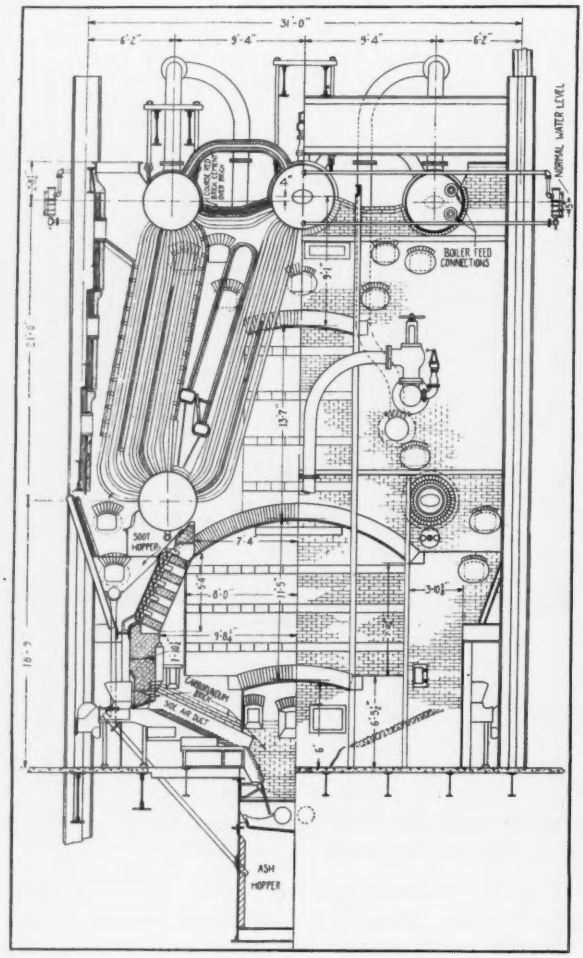


FIG. 3. SECTION AND END VIEW OF 2821-HP. STIRLING BOILER

Tops of the stacks are 80 ft. above the stack girders or 175 ft. above the stokers. Each boiler has its own stack which is of the self supporting steel type, 9 ft. inside diameter. The stacks are lined with brick and grout is poured in between the brick and the steel shell.

Induced draft fans driven by adjustable speed d.c. motors are installed, one for each boiler. The fans and motors are located just below the base of the stack, but the speed adjustment is made by the operator on the boiler operating floor level. No economizers are installed at present, but space is provided for them and with the addition of another motor each induced draft fan will provide sufficient draft under these conditions.

Ash hoppers are of concrete construction each having a capacity of 1154 cu. ft. This will hold the ash for approximately 10 hr. when the boiler is steaming at 300 per cent of rating. The hoppers are provided with air operated gates for ash removal and are of sufficient height above the track, which passes directly underneath, to permit the use of a full height gondola car in removing the ashes from the plant.

All boilers are equipped with Diamond soot blowers of the valve in the head type and Copes automatic feedwater regulators are installed.

In front of each boiler in the center firing aisle is located a boiler instrument and control board shown in Fig. 7. This board contains all instruments and controls needed for the proper control of the boiler, stoker, blower, and induced draft fan. Among the instruments are, indicating and recording pressure gages, a steam flow meter, multi-pointer draft gage, recording overfire draft gage, combination CO and CO_2 recorder and a recording potentiometer which records separately the temperature of the gases leaving each side of the boiler. The controls for the motor driving stokers, blowers and induced draft fans and the main boiler damper are operated by hand wheels mounted on this same board. The controllers themselves are mounted on a framework just below the boiler room floor. Indicating ammeters show the input to each motor.

As stated previously, the present four boilers are sufficient for supplying steam to 50,000 kw. generator capacity. On this basis, the following ratios exist:

Kilowatt capacity for rated boiler horsepower	4.43
Kilowatt capacity per rated stoker retort	446.40
Kilowatt capacity per stoker tuyere	20.30
Kilowatt capacity per cu. ft. of furnace volume	1.29
Kilowatt capacity per sq. ft. of projected stoker area	32.00

Turbine Room

In the turbine room, the turbo-generators are arranged with their shafts lengthwise of the room and so placed that when the plant is completed there will be two rows of machines, one row on either side. The turbines are of the Curtis type manufactured by the General Electric Co. The first unit is a 10,000-kw., 9-stage, 1800-r.p.m. machine with a generator designed for 80 per cent power factor and 4800 v. The second unit is a 30,000-kw., 17-stage, 1800-r.p.m. machine with a generator designed for 90 per cent power factor and 12,200 v. The 10,000-kw. unit has its voltage stepped up to 24,000 v. through three 4166-kv.a. single phase transformers connected delta on the primary and Y on the secondary. The 30,000-kw. unit has its voltage stepped up to 24,000 v. through a 33,333-kv.a., Y connected transformer. Both generators have direct connected exciters. Figure 5 shows a photograph taken looking west toward the 30,000-kw. turbo-generator.

Other electrical equipment in the turbine room consists of two 2000-kw., 4800-v., 3-phase, 60-cycle, 240-v., d.c. motor generators shown in Fig. 5, for supplying direct current to the plant auxiliaries, and one 2000-kw., 4800-v., 60-cycle, 3600-r.p.m. house service turbo generator shown in Fig. 6.

Three boiler feed pumps are also located in the turbine room near the division wall between the boiler room and turbine room. These pumps have a capacity of 1200

gal. per min. at 925 ft. total head. Two pumps are driven by adjustable speed d.c. motors and a third pump is steam turbine driven.

Operating gages and instruments are located on a central gage board which is at the west end of the present turbine room on the boiler room side. This position will be approximately in the center of the length of the turbine room of the completed plant. The instruments placed on this board are for the benefit of the operating engineer who makes this location his headquarters. There are indicating and recording pressure gages on steam, air, and water; recording thermometers and Venturi meters on the boiler feed water; absolute pressure gages on the auxiliary condensers for feed water temperature control; and other miscellaneous gages. Indicating wattmeters and watthour meters indicate and meter the load on the house service transformer, and wattless component indicators give an indication of the power factor. On the board are mounted also the auxiliary circulating pump motor controllers so that the pump speeds may be controlled from this central point to give a supply of feed water equal to the boiler feed pump demand as indicated by the boiler feed tank level recorders.

Directly opposite this central gage board on the switch house side of the turbine room is located the turbine room load indicator, which is duplicated in the center firing aisle of the boiler room. This group of instruments comprises a plant load indicator, a Warren clock and a machine on and off indicator. The load indicator is a large illuminated dial milliammeter which is actuated by the totalizing wattmeter on the central gage board. The Warren clock is driven by a small synchronous motor. The machine on and off indicator indicates the plant number of the machines running, idle, or starting or stopping. This indicator is made up of a series of metal boxes having a ground glass cover with the machine numbers on them and with red and white lights behind the glass. A white light behind the number indicates that machine is running, no light indicates the machine is down, a red light, that the machine is being put on or taken off from the system.

Condenser Room

All the prime mover auxiliaries and some other plant auxiliary equipment is located in the condenser room. The main condensers and their auxiliary pumps comprise the larger portion of the equipment. The condenser for the 10,000-kw. unit has 14,100 sq. ft. of cooling surface and that for the 30,000-kw. unit, 30,350 sq. ft. The latter is arranged with variable tube spacing so as to give a uniform steam velocity through the condenser. The air cooler is self-contained and has the closest tube spacing of any section of the condenser. There is no depressed section in the bottom of the condenser shell for collecting the condensate, the entire bottom of the shell being the hot well. The condensate flows from the shell into a tank and is removed by the hot well or condensate pump. The drains from the turbine casing are piped to this tank to conserve the heat in the

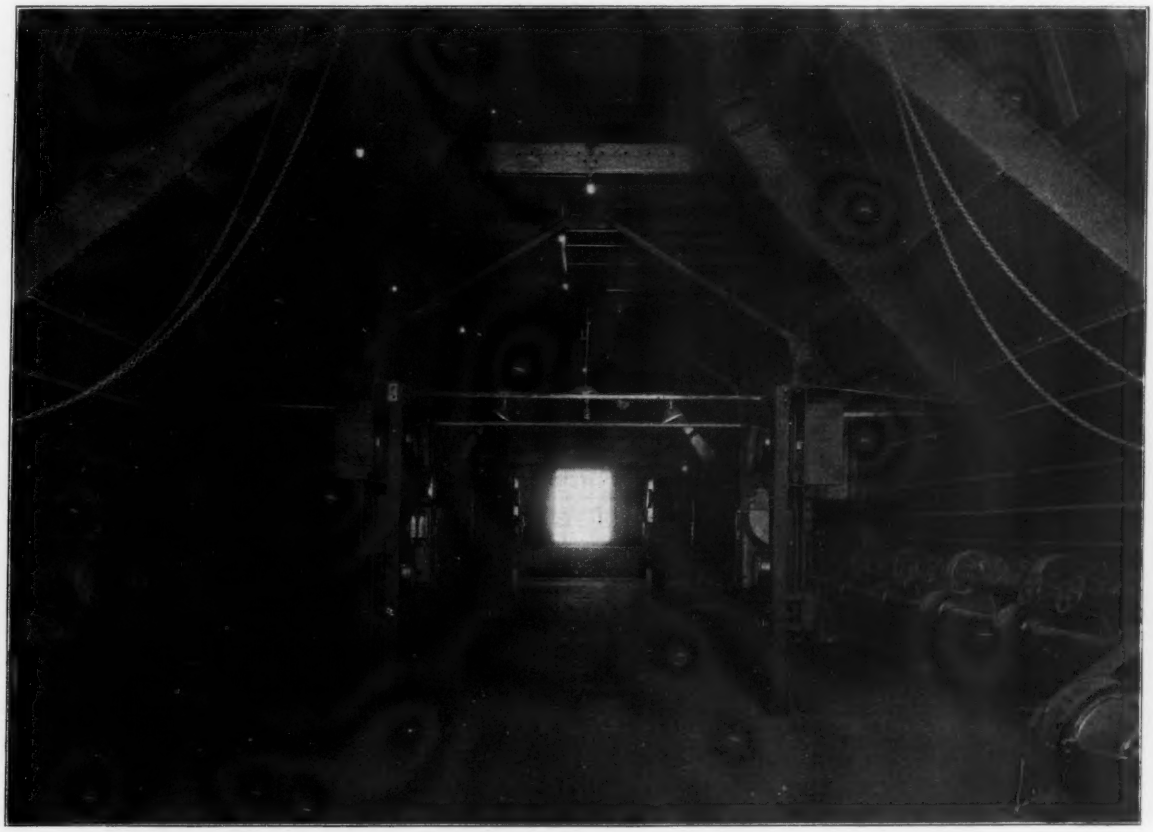


FIG. 4. FIRING AISLE SHOWING ARRANGEMENT OF CONTROL PANELS

Mechanical Equipment at Marysville Plant

Boilers

Manufacturer	Babcock and Wilcox
Number	4
Boiler working pressure	300 lb. per sq. in. gage
Ratio of superheater surface to boiler heating surface	11.23 per cent.

Forced-Draft Fans

Manufacturer	American Blower Co.
Number	6
Type	No. 9 Sirocco double inlet
Speed	525 r.p.m.
Capacity, at 7.25 in. static pressure	103,000 cu. ft. per min.
Drive	Adjustable speed d.c. motor

Induced Draft Fans

Manufacturer	Buffalo Forge Co.
Number	4
Type	No. 11 double inlet, double width, Niagara Conoidal
Speed	835 r.p.m.
Capacity, at 370 deg. F., 8.4 in. static pressure	136,500 cu. ft. per min.
Drive	Direct connected to d.c. motor

Stokers

Manufacturer	American Engineering Co.
Type	Double ended Taylor
Width of grate	24 ft. 7 in.
Length of grate, 2 grates	Projected length, 82 in.
Ratio of water-heating to grate surface	72 to 1
Drive	Adjustable speed d.c. motor; two speed
Coal	West Virginia Semi-Bi.
Ultimate analysis of coal upon which stoker performance is based:	
Moisture	4.58 per cent.
Ash (dry basis)	12.73 per cent.
Heat value (dry basis)	13,000 B.t.u. per lb.

Boiler Settings

Volume of combustion chamber per sq. ft. of projected grate area	24.8 cu. ft.
Arches	None

Turbo-Generator

Rating	10,000 kw.	30,000 kw.
Manufacturer	General Electric Co.	General Electric Co.
Number of units (present section)	2	1
Generator	3 ph. 60 cyc. 4800 v.	3 ph. 60 cyc. 12,200 v.
Exciter, direct-connected voltage	250 v.	250 v.
Rating	75 kw.	140 kw.

Guaranteed performance: Operating conditions, 275 lb. gage, 235 deg. superheat, for 10,000 kw., and 700 deg. total temperature for 30,000 kw., 29 in. vacuum for both.

10,000		30,000	
Output of Generator, kw.	Lb. of Steam per kw. hr.	Output of Generator, kw.	Lb. of steam per kw. hr.
5000	11.45	15000	10.3
7500	10.75	20000	9.85
10000	10.65	26000	9.70
		30000	9.85

Condensers

Manufacturer: No. 1 designed by Detroit Edison Co., built by Russell Wheel and Foundry Co.
No. 2 built by Worthington Pump and Machinery Corp.

	No. 1	No. 2
Surface, sq. ft.	14,100	30,350
Surface per kw. of generator rating	1.41	1.01
Circulating pump capacity, gal. per min.	20,000	80,000
Drive: Direct connected adjustable speed d.c. motor.		
Speed, r.p.m.	400	340
Hot well pump capacity, gal. per min.	300	800
Drive—No. 1. Direct connected constant speed d.c. motor.		
Drive—No. 2. Direct connected adjustable speed d.c. motor.		
Speed, r.p.m.	1150	1150
Air pump capacity, displacement cu. ft. per min.	690	2050

Type—Rotative D.V. Pump—two stage.
Drive—Direct connected d.c. motor.

House Turbo-Generator

Manufacturer	General Electric Co.
Number (present section)	2
Capacity	2000 kw.
Generator	3 ph., 60 cyc., 4800 v.
Condenser	3475 sq. ft.

Feed Water Heaters

Number (present)	2
Type	Reilly No. 86
Manufacturer	Griscom-Russell Co.

Auxiliary Condensers

Number (present)	2
Type	Surface, with external air coolers
Manufacturer	Griscom-Russell Co.
Size	3475 sq. ft.
Capacity	475,000 lb. water per hr. from 85 to 171 deg. F.

Evaporators

Manufacturer	Griscom-Russell Co.
Type	Two effect, submerged type, self-sealing
Capacity, lb. per hr.	11,000
Pumps	Goulds, size 2 L
Capacity, gal. per min.	65
Drive	Direct connected d.c. motor 1150 r.p.m.

Boiler-Feed Pumps

Manufacturer	DeLaval Steam Turbine Co.
Number (present)	3
Type	Centrifugal
Capacity, gal. per min.	1200
Discharge head	925 ft. total
Drive	Two motor and one turbine

Service Pumps

Manufacturer	DeLaval Steam Turbine Co.
Number (present)	3
Type	Centrifugal
Capacity, gal. per min.	1500
Drive—No. 1	Direct connected to d.c. motor
Drive—No. 2	Direct connected to turbine

Miscellaneous Equipment

Inclined steel pan coal conveyors	Link Belt Co.
Coal crushers (2)	Williams Patent Crusher & Pulv. Co.
Distributing belts	Robins Conveying Belt Co.
Bucket elevators	Link Belt Co.
Coal bunkers	Detroit Edison Co.
Superheaters	Babcock & Wilcox Co.
Clinker grinder drives	American Engineering Co.
Fan drive motors	General Electric Co.
Flow meters	G. E. Co. & Bailey Meter Co.
Draft gage	Bailey Meter Co.
Soot blowers	Diamond Power Specialty Corp.
Automatic non-return and throttle valves	Schutte & Koerting Co.
Blowoff and gate valves	Hopkinson
Safety valves	Consolidated
Steam pressure gages	The Foxboro Co.
Recording thermometers & pressure gages	The Taylor Instrument Co.
CO_2 recorder	Mono Corp.
Pyrometer	Leeds & Northrup Co.
2000-kw. M.G. sets (2), 4800 v., 3 ph., 60 cyc., 240 v. d.c.	General Electric Co.
Circulating pump and drive motor	Worthington with G.E.
Gage board	Detroit Edison Co.
Main condensers	No. 1. Detroit Edison Co. No. 2 by Worthington
Traveling crane 100 T. main hook, 25 T. aux. hook	Shaw Crane Works
Condenser pumps	Worthington
Air removal pumps	Worthington
Motor—Turbine driven service pumps	DeLaval Steam Turbine Co.
Intake screens, traveling	Chain Belt Co.
Boiler feed pumps	DeLaval Steam Turbine Co.
Make up evaporators	Griscom-Russell Co.
Transformers	General Electric Co.
Switchboard	Detroit Edison Co.

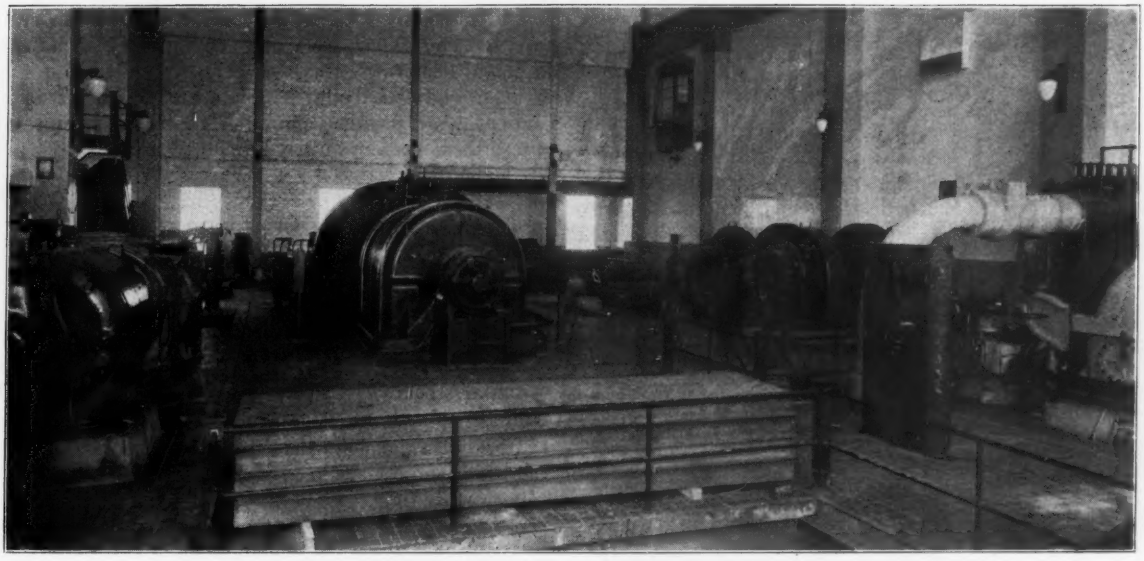


FIG. 5. TURBINE ROOM SHOWING THE 30,000-KW. UNIT IN THE CENTER

drip. An equalizer connection between the condenser and this tank prevents it from becoming air bound. This condenser is a single water pass condenser and receives its water from either or both of two 40,000-g.p.m. pumps driven by adjustable speed d.c. motors. The condensate pumps are in duplicate, either of which will remove the condensate at full load on the turbine. A reciprocating dry vacuum pump driven by a direct connected d.c. motor removes the air from the condenser.

Two motor driven and one steam driven general service water pumps, and an air compressor comprises the general plant auxiliary equipment located in the condenser room. At the east end is the screen house in which are located the motor driven vertical screens through which the circulating water passes on its way from the river to the condensers.

Means are provided for passing part of the water from the discharge canal back into the intake canal on the plant side of the traveling screens, so that in case of blocking of the screens with ice there will still be water available for a short period until the screens can be cleared. This is effected by means of a rotary gate, between the intake and discharge canals, which is operated by means of a large hand wheel in the east end of the condenser room.

Switch House

Transformers, oil switches, busses and the switchboard are located in the switch house, which is at the north end of the building, separated from the turbine room by a wall. The transformers, both main and auxiliary, are located at grade. On the second elevation is located the main station bus. On the floor above are the oil switches and electrical control board. At the switchboard there is a bay window extending into the turbine room so that the operator has a view of the entire

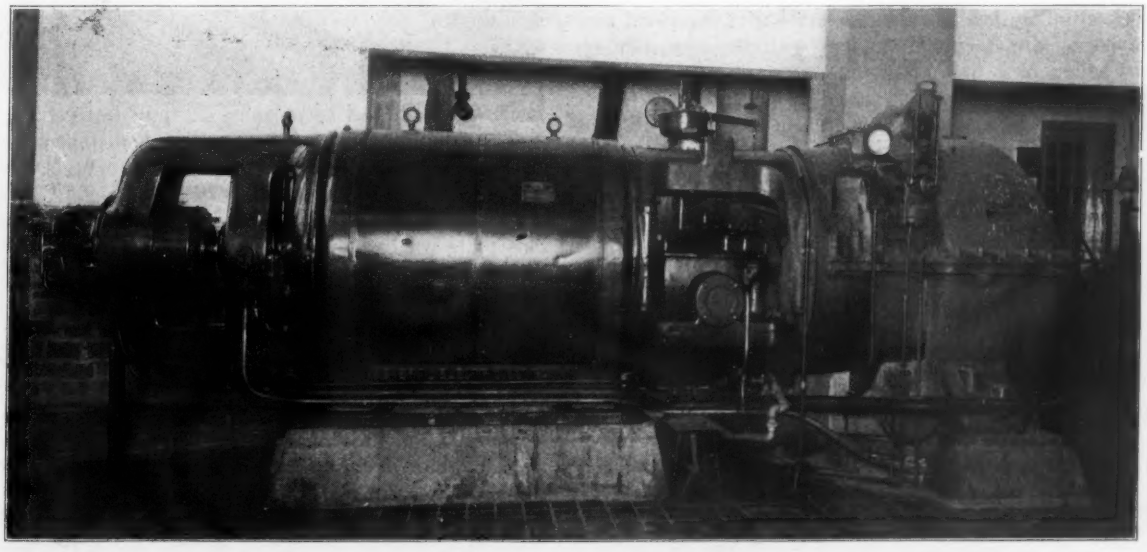


FIG. 6. 2000-KW. HOUSE TURBO-GENERATOR

room and all the machines. The lightning arresters are on the roof of the switch house.

Auxiliary System

For supplying the energy for operating the plant a complete auxiliary generating system with its auxiliary equipment is provided. The prime mover is the 2000-kw. turbo-generator shown in Fig. 6 which generates energy at 4800 v. a.c. Those auxiliaries which are considered

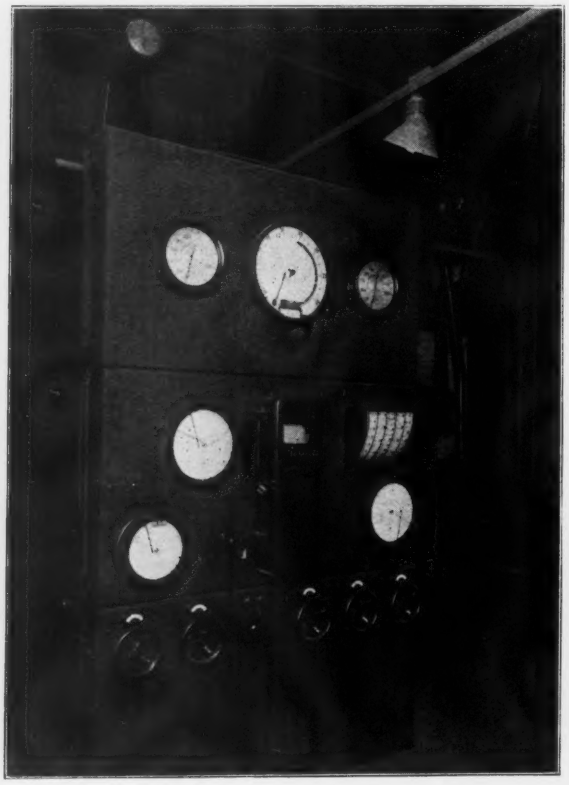


FIG. 7. BOILER INSTRUMENT AND CONTROL BOARD

as essential to the continuous operation of the plant are driven by direct current motors with the exception of one boiler feed pump and one general service pump, these being considered as stand-by equipment. Other equipment whose continual operation is not essential to continuous operation of the plant, such as coal handling equipment, except where adjustment of speed is desirable, are driven by a.c. motors. The direct current is supplied from the two 2000-kw. motor generator sets which may be driven from the 2000-kw. house turbo-generator or from the main system. A storage battery having a 1-hr. discharge rate of 1500 amp. at 240 v. is continually floating in the d.c. bus as a stabilizer to the d.c. voltage and to furnish a source of d.c. supply in case of the temporary loss of a motor-generator. It would be able to supply about 1000 kw. for 20 min. The exhaust steam from the house-turbo-generator is condensed under vacuum in a surface condenser, the circulating water for which is the condensate from the main turbo-generators. This surface condenser then is really the feed water heater, so by varying the output of the house generator, the feed water temperature can be varied.

All make-up water is evaporated in make-up evaporators. The vapor from the evaporators is condensed in closed heaters by the high pressure boiler feed water on its way to the boilers. The steam leakage from the high pressure packing glands of the main turbines also enters these heaters and is condensed, giving its heat to the boiler feed water.

Operation

The Marysville plant was put into regular service during November, 1922, but owing to certain limitations in the distribution system it has not been possible to operate the station at more than half its rated capacity. Further extension of a 120,000-v. transmission line now being constructed will permit increasing the load on the plant to its full rated capacity when desired.

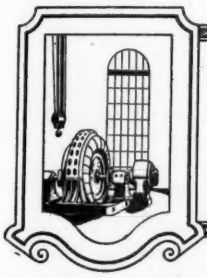
Owing to the short time this plant has been in operation, it is impossible to give representative economy results at this time. With turbines having a lower water rate than those at the Connors Creek plant, and boilers giving higher efficiency, the economy of this plant should show a decided improvement over that being obtained at Connors Creek.

The author wishes to express his indebtedness to Messrs. C. M. Weinheimer and R. B. Purdy, engineers with the company, for their assistance in computing and checking the material presented in this article.

Grounding Plate Buried in Tail Race

The grounding plate for grounding transformers and other apparatus at the Pit River power plant No. 1, is made of steel, 5/8 in. thick, and is 20 ft. long by 8 ft. wide. It has six cables welded on it to secure good contact. This plate was buried in the tail race and connected to the transformers by a copper cable.

Heat absorbed in refrigerating processes is usually measured in British thermal unit, B.t.u. The commercial unit of refrigeration, that is, a ton of refrigeration is the quantity of heat required to melt 1 T. of pure solid ice into water, from and at 32 deg. F. This is equal to $144 \times 2000 = 288{,}000$ B.t.u., since the latent heat of fusion of ice is approximately 144 B.t.u. per lb. The removal of heat at the rate of 288,000 B.t.u. per day of 24 hr. may be termed 1 T. of refrigerating power.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Control for Power Station Auxiliary Motors

A Discussion of the Considerations Involved in the Selection of Control for Power Plant Auxiliaries. By A. L. Harvey*

IN THE SELECTION of the methods of drive for the various auxiliaries in power stations, there is a choice between steam and electricity. In this article, no attempt will be made to discuss just where steam and electric drives should be used as this is mainly a question of heat balance and the solution of heat balance problems is a subject in itself.

When laying out the auxiliary drives, the following considerations must be given attention:

1. Reliability of operation.
2. Correct heat balance at varying loads.
3. First cost.

In modern practice, the following methods of drive are in common use.

(a) Steam turbine drive with arrangement to introduce any surplus steam into the low pressure end of the main units.

(b) Mixed steam and electric drive accomplished either by having a portion of the auxiliaries electrically driven and a portion steam driven, or by some of the auxiliaries being dual driven; i.e., having both motor and turbine to drive them, particularly for exciters and circulating pumps.

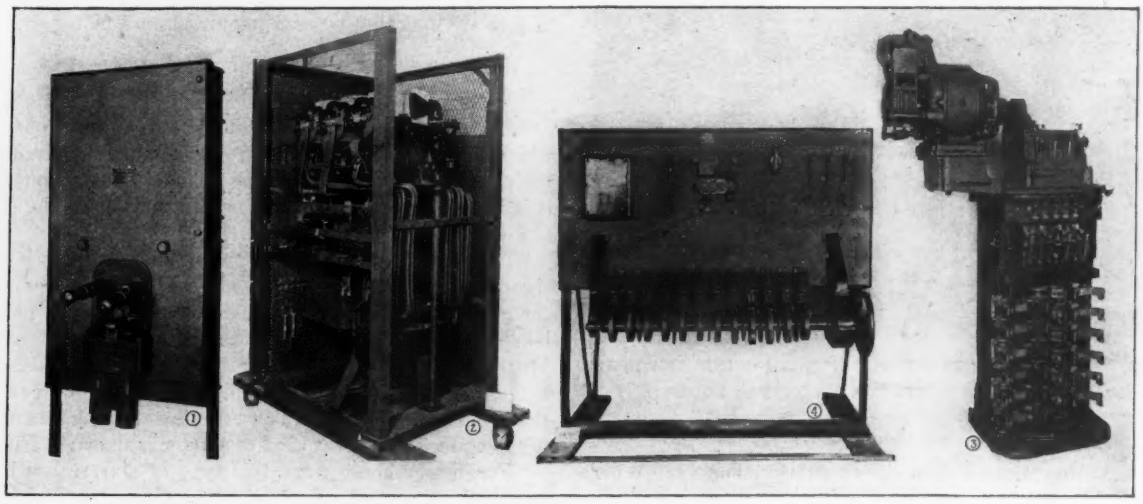
(c) All electric drive with arrangement to bleed out steam from the main units for feed water heating. In some cases, economizers are also used.

(d) All or principally all electric drive with the bulk of the motor supplied from a separate turbo generator (called a house turbine). The house turbine is generally operated with a jet condenser used as a feed water heater, the condensate of the main units being used as injection water.

(e) Method d, combined with the bleeding of steam from the main unit into one or more closed heaters.

In large plants, house turbines show additional saving over other schemes, due to lower auxiliary water rate and the possibility of operating house turbine under a vacuum at light loads. It is also a material advantage in reliability to have separate generating units to supply the more important auxiliaries.

In connection with the motors and control equipment for the auxiliaries, the fundamental requirements are ruggedness of equipment and continuity of service. The operation of large units of 30,000 kw. or more should not be endangered by an auxiliary motor or control equipment. These large units often operate for two or three months without shutting down, and there is little



FIGS. 1-4. VARIOUS FORMS OF CONTROL EQUIPMENT FOR ELECTRICALLY DRIVEN AUXILIARIES

Fig. 1. Circuit breaker type of auto starter for manual operation. Fig. 2. Manual starter for low voltage squirrel cage motor. Fig. 3. Motor operated cam contactor controller for draft drives. Fig. 4. Panel mounted cam contactor controller for condenser circulating pump drive.

*Engineer, Westinghouse Electric & Manufacturing Co.

opportunity for inspecting equipment while in service. The power requirements for the auxiliaries in a large power station are so great that the whole design should be handled from the viewpoint of a large sub-station located in the power house. The currents which can flow under short-circuit conditions are so large that standard industrial control *in many cases is not suitable.*

To appreciate the amount of power required for auxiliaries, we find that in several recent large stations the auxiliary equipment is between three to eight per cent, and in some cases more, of the generating capacity in kilowatts.

Alternating Current Versus Direct Current

Since all large central stations generate three-phase alternating current it is more desirable to use

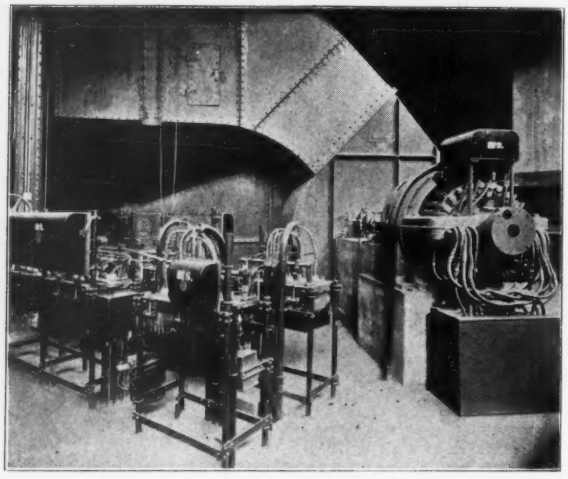


FIG. 5. BRUSH SHIFTING MOTOR DRIVING INDUCED DRAFT FAN AT HELL GATE STATION. CONTROL EQUIPMENT AT LEFT

alternating motors than direct current motors. Where methods B and C are used, alternating current is generally the only supply available.

Alternating current motors have the advantages of simple and rugged construction, with lower first cost and maintenance. Alternating current is not as suitable as direct current where a considerable speed variation is required. The condenser auxiliaries are generally constant speed, but the boiler auxiliaries (forced and induced draft fans and stoker motors), require varying or adjustable speeds.

Direct current can be obtained by means of direct current geared turbo generators, synchronous converters or motor generator sets.

Voltage

Where alternating current motors are used in large plants the voltage of the auxiliary should be 2500 v. for motors of 75 hp. and over, and 440 v. for smaller motors. The amount of power required is so large that a voltage lower than 2500 v. gives a greatly increased first-cost due to the heavy circuit breakers and the large size of bus bars and cable.

If direct current is used 230 v. will probably be adopted, although some plants, particularly those supplying railway load, may use 600 v. If only a portion of the auxiliaries, such as stoker and clinker grinder motors, are driven by direct current motors, 230 v. is more suitable as it is easier to build adjustable speed motors for 230 v. in the sizes used for these applications than it is to build them for 600 v.

Contactors

Contactors, though they can handle heavy starting currents, do not have a large rupturing capacity and can not be depended upon to rupture more than six to eight times approximately the full load rating. If alternating current magnets are used, taking their supply from the same source, a short circuit may drop the voltage low enough so that the contactor opens up and the motor stops. For this reason, some companies use direct current control circuits for the alternating current motors.

The temperature rise of contactors is far greater than in switchboard practice, and where lower temperatures are required a type of control having coils in circuit only during the starting period may be used. As for example, a cam type of controller in which the contactors are operated by cams mounted on a motor driven shaft.

Starting Equipment for Squirrel Cage Motors

As there are many constant speed applications on which squirrel cage motors are used, such as circulating pumps, house pumps, air pumps and hot well pumps, it is desirable to group together information on the control equipment for such motors.

The standard industrial type of auto starter is designed to rupture the locked current of the motor and their use, therefore, cannot be recommended in a power house where the current, in case of a fault, will reach great values. The next larger size of starter consists of a modified double throw circuit breaker, or of two or three separate circuit breakers for the starting and running connections. This kind of starter is shown in Fig. 1.

For power house work this type of starter has been supplied on a steel panel, with the sides, top and rear enclosed in sheet steel or grill work.

For starters where the current is high, as for example, for 300 hp., 220 v., a cam contactor type of starter, as shown in Fig. 2, can be used. This consists of a panel on which is mounted a circuit breaker of suitable rupturing capacity and a cam controller for starting. The controller has contactors which can carry the heavy currents. During starting, the overload attachment on the circuit breaker is short-circuited. The controller transfers one phase at a time from the starting to the running position, hence prevents any transient rush of current and also reduces the normal rush of current which ensues when the motor is thrown from starting to the running position.

When the starting bus is available, two breakers (a running and starting breaker) suitably interlocked, can be used.

Starting Equipment for Wound Rotor Motors

For wound rotor motors the principal types of starting equipment are as follows:

(a) Control panels with primary circuit breaker and secondary drum.

(b) Drum controller with separate breaker or contactor for the primary.

(c) Motor operated controller with separate breaker or contactor for the primary.

(d) Motor operated liquid rheostat with separate breaker or contactor for the primary.

(e) Motor operated face plate with separate breaker or contactor for the primary.

(f) Contactor type controller.

In some cases it is desired to have both the primary and secondary controlled from a remote point. For this case, a motor operated or contactor type controller is used. The pilot motor is controlled by forward and reverse relays where changes of speed are required. These relays are controlled by push button stations located on the operating floor. A controller of this type is shown in Fig. 3.

Starting Equipment for Direct Current Motors

For the smaller motors driving stokers and clinker grinders drum controllers similar to those used for machine tool service are applicable. For larger motors, contractor type as well as other controllers have been used.

While continuity is important in the case of all power house auxiliaries, it is especially important in the case of condenser auxiliaries as a brief shut down of this apparatus may necessitate the shut-down of a main generating unit. Considerable attention is now being given to the behavior of this equipment in the case of voltage disturbance in the supply circuit. Differential protection for motor and leads is sometimes used instead of overload protection so that the motor will trip off in case of trouble within itself, but not in cases of excessive current due to under-voltage. There is an increasing tendency in modern stations to provide differential protection for large alternating current motors. To apply this protection to the motor six leads must be brought out, and six current transformers and three relays provided. If the circulating water is lost and the condenser heated up it takes considerable time to reestablish the circulating system. It is, therefore, questionable whether equipment for automatically restarting on return of voltage is necessary, although this can be supplied wherever contactor type of electrically operated control equipment is used. Some companies are asking for motors even in rating of 200 to 300 hp. that can be started by throwing direct on the line.

Motor Operated Drum Contactor Controllers

Among the controllers that have been supplied for central station service are those consisting of motor operated cam contactors for the secondary of wound rotor motors driving circulating pumps. The primary is controlled by an oil circuit breaker, or if there are two sources of power, two breakers are used with a selective push button scheme to operate either breaker. Speed control switches may be included on the panel so that reduced speeds can be obtained. This controller is of the pre-set type, the motor accelerating to the speed for which the speed switches are set. In order to give the operator some control over the time of acceleration a time limit relay is supplied which delays the starting of the pilot motor a certain length of time after the release of the start push button. A similar relay is also provided for low voltage protection that will cause the controller to cut in all resistance after a pre-determined length of time following power failure. A controller of this type is shown in Fig. 4.

Boiler Draft Fans

Forced draft fans are required for underfeed stokers and for some chain grate stokers. In many cases induced draft fans are necessary when economizers and low stacks are used. The proper control of the forced and induced draft fans determines the efficiency of boiler operation. Also, the forced and induced draft fans are interlocked in such a manner that should the induced draft fan motor shut down, the forced draft fan motor will also stop to prevent blowing the fire out of the fire doors and possibly burning a boiler room attendant.

The fundamental law of a fan is that for constant discharge the pressure varies as the square of the speed, the volume varies directly as the speed and the horsepower varies as the cube of the speed. In most cases a speed variation of 2 to 1 will take care of the range through which modern boilers are worked, generally from 150 to 300 per cent of the normal boiler rating.

With alternating current motors, the following methods of drive are frequently used:

1. Constant speed squirrel cage motors with damper control.
2. Wound rotor motors with varying speed control.
3. Two-speed squirrel cage motors with damper control.
4. Polyphase commutator alternating current motors.
5. Two-motor drive, having motors of different capacities and speeds and using speed control for intermediate boiler outputs.

Tests made by one of the large companies indicate that the use of the wound rotor motors with varying speed is about 10 per cent more efficient than the use of a constant speed motor with damper control. Using wound rotor motors with speed control the efficiency is poor but the losses are not unduly high, because the horsepower requirements decrease as the cube of the speed.

Recently attention has been given to the use of polyphase commutator motors. These motors have good efficiency, but high first cost and high maintenance on account of the commutator and large number of brushes, and rather complicated control equipment. A view of the brush shifting induced draft fan motor and control equipment installed at the Hell Gate station is shown in Fig. 5.

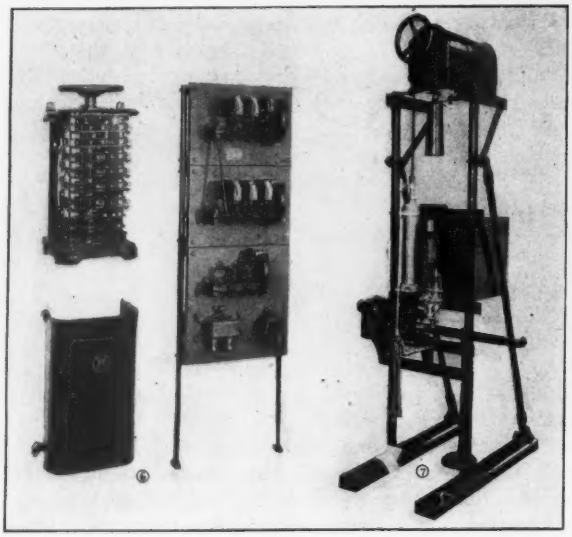
Stoker Drive

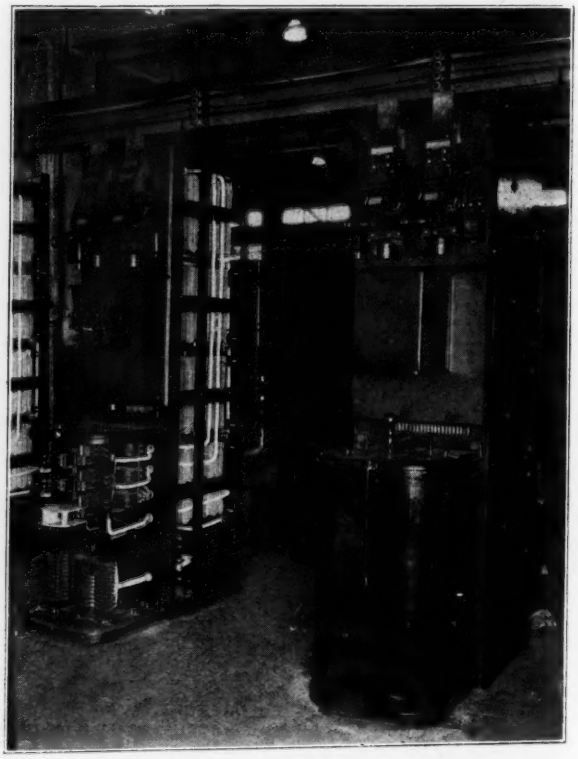
As the load on stokers is variable under different operating conditions, in many cases wound rotor motors with speed control and armature control on direct current motors have not been entirely satisfactory. Among the conditions affecting the load are the thickness of the fuel bed, the size of coal, the amount of moisture in the coal and relative position of the rams.

Speed ranges for stoker motors varies between 2 to 1 to as high as 4 to 1. The service is generally considered as a constant torque application, although some tests indicate that the torque increases at the lower speeds. When wound rotor motors or armature control on direct current motors are used, the variations in the torque

requirements, especially at the low speeds, are very apt to cause the motor to stall. This condition is overcome by the use of a shunt wound direct current motor with shunt field control, which makes an ideal motor for this application.

As stated above, the torque sometimes rises on the lower speeds. When used with a gear box, this means that the stoker speeds on any one notch of the controller with different gear speeds will not be in the same ratio as the ratio of the gears. Also the motor, still running with the same secondary resistor and with a 2 to 1 gear ratio, has only to develop one-half the torque to produce the desired speed on the stoker shaft as when the stoker is running at higher speed. This also further affects the speed control that is obtainable. On account of conditions such as this, the use of wound rotor motors on stoker drive with automatic regulators will not always





TYPES OF CONTROL UNITS FOR USE IN THE BOILER ROOM

Fig. 6. A. C. stoker controller and pole changing contactor panel. Fig. 7. Pressure regulator operated drum controller with protective panel. Fig. 8. Direct current manually operated control panels for 450 hp. boiler feed pump

be successful. It is necessary to use some type of equipment that does not use a mechanical gear shift as the regulator equipment can not be readily made to shift the gears.

As the horsepower requirement of a new stoker is usually much higher than that of one which has been worn in by use, due to the rough castings, it is necessary that the armature or secondary resistance be designed with sufficient capacity for the initial load and with sufficient ohmic value for the ultimate load. The usual equipment for the direct current motors for stoker drive consists of a protective panel to give overload and low voltage protection, and a drum controller and resistor.

With alternating current motors the use of 4 to 1 speed range is usually a rather hard condition to meet. The different methods of obtaining the variable speed are as follows:

(a) A constant speed motor with a mechanical speed changing device, such as a gear box or a variable speed transmission.

(b) A wound rotor motor with 2 to 1 speed control by resistance in the secondary and a 2 to 1 gear box giving a total of 4 to 1 speed range.

(c) A 4-speed squirrel cage motor giving speeds corresponding to 6, 8, 12 and 16 poles, with a 2 to 1 ratio gear box giving in addition 300 to 225 r.p.m., or in all 6 fixed speeds.

(d) A 2-speed wound rotor motor giving speeds of 1200 and 600 r.p.m. by pole changing, with speed control by secondary resistance, thus obtaining a total range of 1200 to 300 r.p.m. Hand operated control equipment for this service is shown in Fig. 6.

There is a considerable demand for automatic regulation on the boiler room equipment. In the large station, this is applied to boiler feed pumps, forced and induced draft fans, and sometimes to stokers. Figure 7 shows a small control equipment, consisting of a regulator-operated drum controller, and an enclosed protective panel, for use with an adjustable speed d.c. motor.

It is unsettled whether the stoker motor and the fans should be regulated together or whether the fans alone should be regulated. It would seem desirable to feed in the coal at an average rate rather than attempt to follow the variations of the load curve.

Miscellaneous Applications

Among the miscellaneous applications for the electric motors are used service pumps, fire pumps, boiler feed pumps, air compressors, dual drive exciters and coal handling equipment. Each of these applications is considerably different from the others and takes a different type of control. Service and fire pumps are usu-

ally driven by squirrel cage motors and are run at constant speed. The boiler feed pumps are very frequently controlled by automatic regulators and these motors will then have to be of the adjustable or varying speed type.

On large dual drive exciter sets the motor may be of the wound rotor type to reduce the starting current. The control equipment may be any of the types previously given for this type of motor. The air compressor may be driven by either synchronous or wound rotor motors.

For the coal-handling equipment the main consideration is to provide a suitable scheme of interlocking so that the coal will not pile up should a conveyor stop.

Binary Vapor Engine

By Robert Grimshaw

WHILE THE term, binary vapor engine is not a familiar one, it is employed because it is both definite and appropriate. A binary vapor engine differs from a binary engine just as a part differs from the whole. All binary vapor engines are binary engines, just as all beef is meat, but the converse is not true in either case.

To be more specific, however, a binary vapor engine is a contrivance for increasing the range of temperature change in the Carnot or the Rankine cycle, by accomplishing at the exhaust end of the engine what superheating does at the admission side. The objects of the ordinary water cooled exhaust condenser are to utilize heat units that might otherwise be wasted and, especially on shipboard, to save water. The first of these objects, it can, and does attain, but imperfectly, principally on account of financial reasons. For while ordinary condensers, even the high vacuum type with "rain pans" and Parsons "vacuum improvers"—could produce better vacuum than they do, it would not pay. Below 26 in. of mercury the rapidly increasing volume of expanding steam would call for air pumps and connections so large, heavy and expensive, that pressure reduction, which still leaves the steam with a temperature of about 100 deg. F., has been accepted as the commercially best paying limit.

Steam at 2 lb. absolute pressure and (say) at 126 deg. F. (25.85 in. of mercury), takes up 173.5 cu. ft. per pound. At 1 lb. absolute (27.22-in. vacuum), it occupies 333 cu. ft. or nearly double the volume; and if we get the vacuum down to 29 in. the steam would take up about 800 cu. ft.

If, now, we substitute for the cooling water in the condenser as ordinarily used, a liquid of lower temperature than the exhaust, but having a boiling point much lower than that of water, we can reduce the volume of the exhaust, while extracting from it a certain amount of heat that generates from the cooling liquid a vapor that can be used to drive an engine, and after doing that can be condensed by cooling water (just as exhaust steam is in an ordinary condensing steam engine) and returned to the tank.

There are several liquids which boil at a much lower temperature than that of exhaust steam at 26-in. vacuum. One is carbon disulphide, the boiling point of which at atmospheric pressure is only 118 deg. F.; another is sulphuric ether, 100 deg. F.; a third is sulphur dioxide (SO_2), which evaporates at about 17 deg. F.

It so happens that of these three the only one that would not offer insurmountable practical obstacles to use as a condensing liquid, is the sulphur dioxide, which is not inflammable, does not attack metals or dissolve ordinary lubricants, and is, in fact, itself a good lubricant.

Using SO_2 the cycle, then, in its most simple form, may be as follows: Steam cylinder—combination steam condenser and SO_2 vaporizer—SO_2 working cylinder—SO_2 condenser with cooling water—SO_2 tank; and so on around again, as far as the SO_2 is concerned, to the SO_2 vaporizer; and the air pump takes care of the air in the condensed steam.

Instead, however, of inserting the SO_2 vaporizer at the exhaust of an ordinary high-pressure steam engine, it may preferably take that of a low-pressure cylinder; and better still, come fourth in a series in which it is preceded by the low-pressure and the intermediate cylinder in a three-stage expansion machine.

Experiments made on such a combination in Berlin gave temperatures, pressures and horsepower as follows:

	Temp. F.	Press. lb. abs.	I.H.P.	Percent power
H.P. steam cylinder	590°	173	68.6	32.5
Int. steam cylinder	...	...	43.2	20.5
L.P. steam cylinder	155°	4.2	42.4	20.1
SO_2 vaporizer and steam condenser	148°	187	...	...
SO_2 cylinder	72°	51.6	56.8	26.9
Liquid SO_2 tank	67.6	...	...	...
Circ. water, in	49.8	...	...	...
SO_2 condenser	70°	49.5	...	...
Circ. water, out	62.7	...	...	...
Total H.P.			211.0	100.0

Joose's experiments on an engine of 200 hp., with superheater steam, showed the following:

	Hp.	Percent power
Steam end	146.4	73.5
Steam per i.hp.-hr., steam end	12.8	
SO_2 end	52.7	26.9
	199.1	100.4

Steam per i.hp.-hr., combined engines, 9.43.
Inc. steam consumption per i.hp.-hr., steam alone, 35.7.
Saving in steam by combination, 26.5.

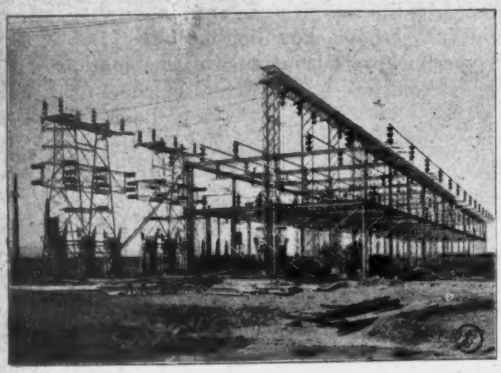
The steam consumption per indicated horspower-hour above given has been lowered to 8.36 lb., corresponding to about 9500 B.t.u. per hr.

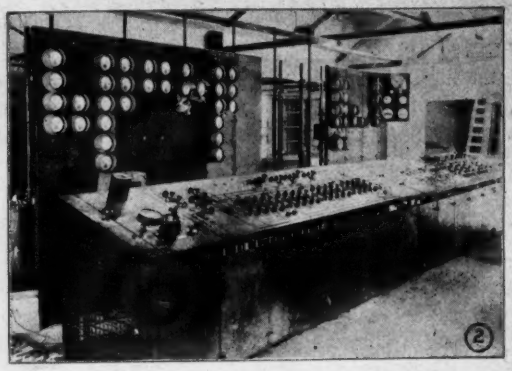
Induction Motor Efficiency at Reduced Speed

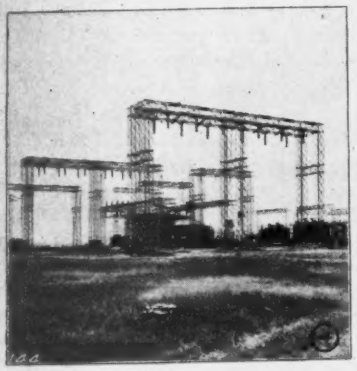
When an induction motor is operated at reduced speeds by increasing the slip as by increasing the secondary resistance or decreasing the primary voltage, the efficiency is lowered by an amount nearly proportional to the speed reduction, as expressed by the formula $E_2 = E_1\left(\frac{100 - S_2}{100 - S_1}\right)$, in which E_1 = the efficiency of the motor when running at a given torque and a slip S_1. E_2 = the efficiency when the motor is developing the same torque, but with a different slip S_2, efficiencies and slips being expressed in per cent.

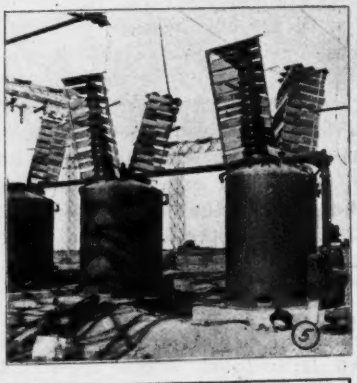
World's Highest Voltage Substation

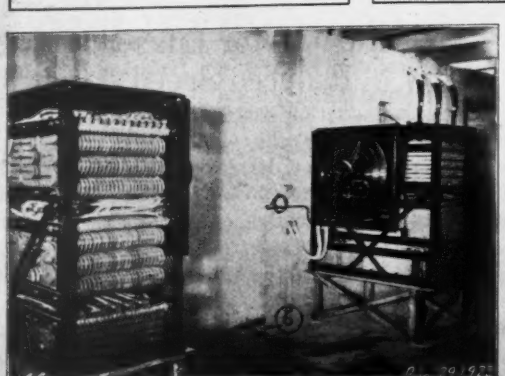
Fig. 1. The 100 kv. double bus structure. Fig. 2. The benchboard from which the 220 kv. as well as the lower voltage switches are controlled. Fig. 3. One of the synchronous condensers. Fig. 4. The 220 kv. bus structure. Fig. 5. One of the 220 kv. solenoid operated breakers. Fig. 6. Motor operated rheostat for synchronous condenser. Fig. 7. Another view of the 100 kv. bus structure

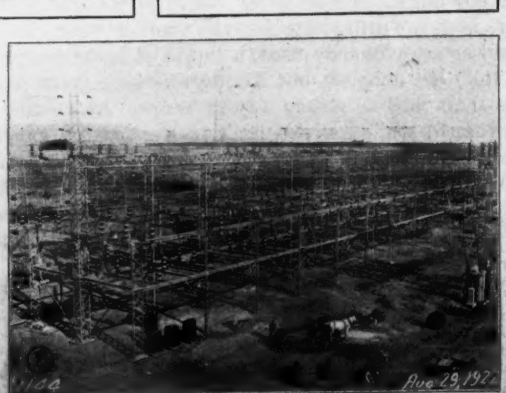












Features of the Vaca Substation

PACIFIC GAS AND ELECTRIC CO.'S LARGEST SUBSTATION PRESENTS INTERESTING FEATURES. BY C. W. GEIGER

IN THE photographs on the opposite page are shown some of the interesting features of the Vaca substation of the Pacific Gas and Electric Co., the first substation in the world to be constructed for 220,000-v. operation.

This station is located between Vacaville and Sacramento, 4½ mi. northeast of Vacaville, and is built on a 90-acre tract fronting the state highway between the two towns. At present, the station is the terminal of the 220,000-v. transmission lines from the Pit River power development, and serves two purposes: first, to transform the Pit River power from 220,000 v. to 110,000 v. so that it may be distributed to the cities and regions bordering San Francisco Bay; and second, to regulate the voltage of the power received and thereby secure the most economical transmission and the best service.

As will be noted from the photographs, all high tension equipment, including the main transformers, high tension oil switches, high tension air switches, busses, etc., is installed outdoors. Transformer equipment comprises seven 16,667-kv.a., single phase, oil insulated, water cooled auto-transformers, 220,000 v. high tension, to 100,000 v. low tension with tertiary winding for 11,000 v., for synchronous condensers and with tap for operating at 160,000 v. One of these units is to be held as a spare.

DETAILS OF BUS STRUCTURE

THERE IS a seven-section, 110,000-v., double bus structure, with disconnecting switches and seven 110,000-v. oil switches, and three 220,000-v. oil switches. Each oil switch is provided with bypass and disconnecting switches. All switches are mounted on fireproof steel construction.

In Fig. 1 is shown the 100-kv. double bus structure. The oil circuit breakers may be seen at the left, with the disconnecting and bypass switches mounted on the tower. One of the potential transformers is mounted on the small steel structure at the extreme left. The 220-kv. bus structure is shown in Fig. 4; in this view, however, the oil switches and disconnecting switches are not yet in place. Another view of the 100-kv. bus is shown in Fig. 7. Two-inch, I. D. copper tubing is used for bus conductors.

Transformer units are of the circular coil core type with conservators. Each unit is designed to deliver 16,667 kv.a. at 100,000 v. with an input of 15,000 kv.a. at 200,000 v. and 13,333 kv.a. supplied by synchronous condensers to the 11,000-v. tertiary winding.

Equipment was furnished by various concerns, the General Electric Co. furnishing the 115,000-v. FHKO-36 oil circuit breakers, the switchboard, all 15,000-v. breakers, and the seven 16,667-kv.a. combination auto-transformers and transformers.

One of the 220-kv. oil circuit breakers may be seen in Fig. 5. These breakers are solenoid operated, have a normal rating of 400 amp. at 220,000 v. and a rupturing capacity of 2400 amp. at 220,000 v. They were made by the Westinghouse Electric and Manufacturing Co. and are fitted with the condenser type of bushings.

The main substation building, designed in an adaptation of the Spanish Renaissance, consists of a main front portion 42 ft. 8 in. by 128 ft. in plan, one story high with a rear wing 38 ft. 2 in. by 91 ft., two stories high. The front of the building houses two 20,000-kv.a., 11,000-v., three-phase, 60-cycle, 60-r.p.m. synchronous condensers with direct connected exciters. One of the synchronous condensers is shown in Fig. 3. These machines are virtually alternating current generators and could be used as such, if prime movers were connected to them. A flange has been provided on the shaft for this reason.

Inside the building a large traveling crane is installed to handle equipment and also transformer parts, since the transformers can be rolled into the building over standard gage tracks provided for the purpose. The 11,000-v. bus structures and switching devices are housed on the first floor of the rear wing, while the second floor includes the point of control for all equipment, and contains, in addition to the switchboard, a store room, telephone booth and lavatory.

This floor is reached by two flights of ornamental iron stairs leading directly to the floor level of the main building. Another flight of stairs in the rear end of the building leads down to the level of the outdoor bus structure. The operator is able to get a good view of the condenser room from the office balcony and can also see the exterior bus, the oil and the air switches.

Figure 2 shows the switchboard in course of erection. The switches on the 220-kv. incoming lines, the outgoing 100-kw. lines, the transformers, and the 11-kv. switches for the condensers are controlled from this bench board.

In Fig. 6 is shown one of the motor operated field rheostats for the synchronous condensers. These are located in the basement of the switch-house and are controlled from the switchboard.

BUILDING IS ATTRACTIVE IN APPEARANCE

ONE FEATURE of the Vaca substation which serves to distinguish it from the usual type of substation, is its attractive appearance, considered from an architectural viewpoint. The building is a steel and reinforced concrete structure with Spanish tile roofing, and an outside finish of light buff plaster. The predominating exterior feature on the front of the building consists of a semi-circular niche with an ornamental cast cement emblem overhead and framed with an ornamental lattice border. Circular steps form the approach to the enclosure from which the public will be able to obtain a good view of the interior of the station. An artistic pond with fountain will be located immediately in front of the building, giving a pleasing appearance to the substation setting. It will be the largest and most important substation on the Pacific Gas and Electric System.

There will be eight cottages for the accommodation of the operators, a large garage, and a separate building housing the pumping plant for cooling water and for domestic use.

Steam Condenser Development and Practice

CONDUCTIVITY TESTS; METHODS OF CLEANING TUBES, AND DETECTING CAUSES OF CORROSION ARE DESCRIBED. BY FRANK G. BOYCE* AND J. W. MACKENZIE**

SINCE THE early developments of steam power generation the use of condensing equipment in connection with steam prime movers has been recognized as a necessity. Until a relatively recent date, however, due to the use of steam engines, vacuums of 26 to 28 in., referred to a 30-in. barometer, were considered good practice and were as high vacuums as it was practical to maintain. With the development of the steam turbine, the available energy resulting from higher vacuums became apparent and condensers began to assume proportions which had previously never been thought of.

First steps toward obtaining this higher vacuum were in the direction of increasing the tube surface and this was carried to such an extent that in one instance at least 9 sq. ft. of cooling surface was provided per kilowatt capacity. Contrary, however, to the expectations of the engineers, this great increase in tube surface did not bring the correspondingly higher vacuum which they had expected and showed that the real cause was not due to the lack of cooling surface.

Extensive studies to determine what changes were necessary to obtain vacuums ranging from 28 in. to 29 in., revealed the fact that small amounts of air leakage were influencing the available vacuum much more than had previously been thought, and that the air removal equipment which had previously been considered adequate was found to have had too great a cylinder clearance, and too large ports to make it possible to remove the air from the condensers under the extremely low pressures. This resulted in new developments in the nature of air removal equipment, some of the more recent of which are the various types of steam jet ejectors.

Small air leaks, such as formerly existed around valve stems, piston rods, and in some cases in the piping and shell of the condenser itself, were found to have a much greater effect than had been anticipated, and new energy was put forth in the way of eliminating all possible air leakage, no matter how small.

Whereas, the use of a candle had been sufficiently sensitive to locate air leaks with engine driven equipment, this method of testing became totally inadequate in determining the small air leaks which are due to porous castings or which develop in the joints in the condenser shell, around gage glasses, and other small connections. As a result of this condition, it has become quite common practice for condensers to be filled with water on the steam side to the highest possible point on the turbine casing in order that the small leaks may be detected by the water oozing through the defective joints or packing. This method is effective but, of course, requires that the unit shall be out of service for a number of hours. It also requires careful supervision in order to make sure that all water is drained from the condenser and turbine casing, and to be sure that all operating equipment is put in its normal condition before the unit is again started up. The difficulty in making these tests made it apparent that some means should be devised, if possible, to determine whether or not air leaks existed before such a test should be applied.

As a result of this, some companies have made it a practice to shut off the connection between the condenser and the air pump at regular intervals under normal load conditions, and determine the rate of drop in vacuum. It has been found in general that a drop of 1 in. in 15 min. shows a condenser and system to be relatively free from air leaks, but is a better condition than exists in a great many plants at the present time. Where the test shows that the leakage is in excess of this amount, the water test should be resorted to in order to determine the location of the leaks so that they may be eliminated. The size of the turbine and the condenser has little effect upon the length of time

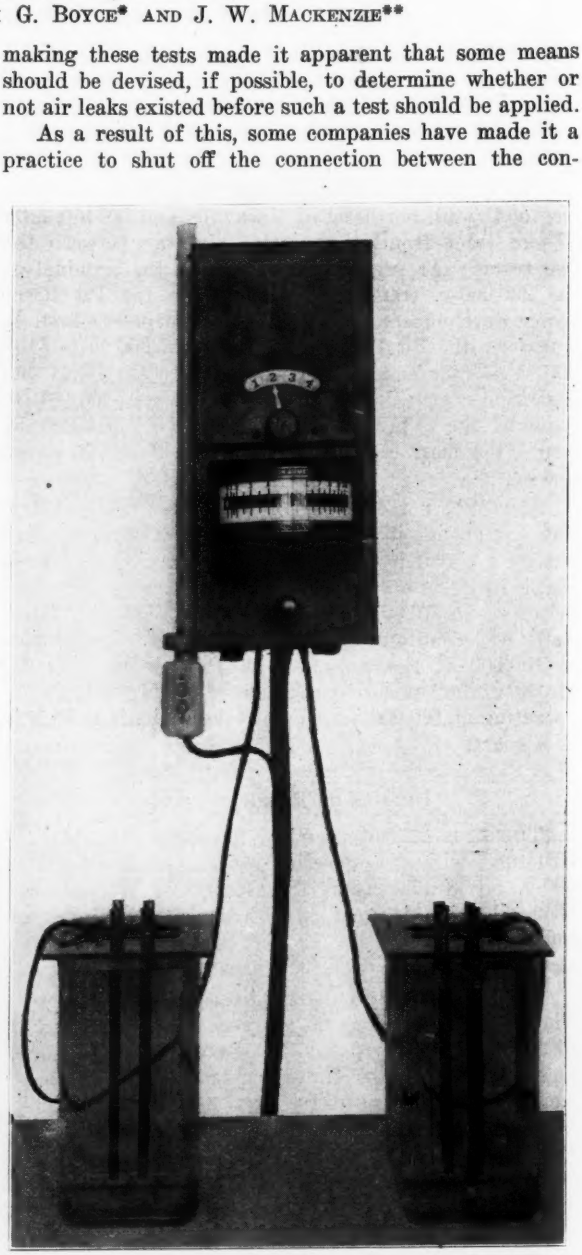


FIG. 1. APPARATUS FOR DETECTING CONDENSER LEAKAGE BY MEASURING ELECTRIC CONDUCTIVITY OF CONDENSATE

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**Operating Mechanical Engineer, Consumers Power Co.

it should require for this drop in vacuum, since the volume of the condenser increases as the capacity of the unit increases, and the percentage of leakage would be practically the same.

From these tests and special investigations, it has become apparent that one of the chief sources of air leakage was in the expansion joint between the turbine and the condenser, and as a result of this condition, it has become quite common practice to mount the condenser on springs, connecting the condenser shell rigidly to the turbine exhaust casing, and thus eliminate the expansion joint. This has helped materially in eliminating air leaks and making higher vacuums possible.

With the development of condensers so that the air leakage was reduced to a minimum, and the air removal equipment developed to such an extent that high vacuums were obtainable, it became evident that air pockets frequently existed in the tube banks and it has been only recently that any steps have been taken to overcome this condition. A study of this condition has brought a much closer co-operation between the steam turbine manufacturers and the condenser designers, as it is found that the same conditions in the reverse order take place in the condenser as those which occur in the turbine; that is, in the turbine the volume of the steam is increasing as it passes through the turbine, due to the decrease in pressure, whereas the volume of steam continually decreases as it passes through the condenser, due to the condensation of the vapors.

With the development of higher ratings in boiler operation, it is necessary that only pure water, or at least water free from all scale forming properties, should be used for boiler feed; therefore, small amounts of leakage of the cooling water into the steam space of the condenser which were not sufficient to affect the vacuum in any way, are likely to cause serious scale troubles in boilers. In the early condenser construction, it was quite common practice to use wood ferrules for packing the tubes in the tube sheet. This method had the decided advantage in being low in first cost, but it was soon found that better economy was possible by providing better packing for the purpose of insuring less leakage in the condenser. In order to reduce the leakage at the other end, which must be free for expansion of the tube, the common corset lace packing was developed, and it was found that one-half of the packing could be eliminated by rolling the tubes into the tube sheet at one end. Since then we have also had the fiber packing and metallic packing developed for condenser tubes, and the relative merits of these different types of packing seem to vary somewhat according to the locations where they are used and is still a disputed point among engineers.

Need of maintaining condensers with practically no water leakage makes it necessary to be able to detect any leakage which might exist and to determine the amount. Several methods have been devised to accomplish this purpose, some of which, while proving perfectly satisfactory in certain localities, are wholly inadequate for the conditions in other parts of the country. Such a one is the chemical test of a sample of the water taken from the condenser. This test is perfectly satisfactory where the cooling water contains such soluble salts that a chemical test will show the presence and percentage of a small amount of them. In cases where the salts are of such a nature as not to be readily determined by chemical test, this method is of little value. Another method which has been developed and which proves satisfactory under some conditions, is the use of an electric tester so constructed that a sample of water can be placed within the tester which is provided with two electrodes located at a fixed distance apart and the amount of current which can be passed through the water with a definite potential difference between the electrodes is indicated on a sensitive ammeter. This method is satisfactory where the chemical salts in the

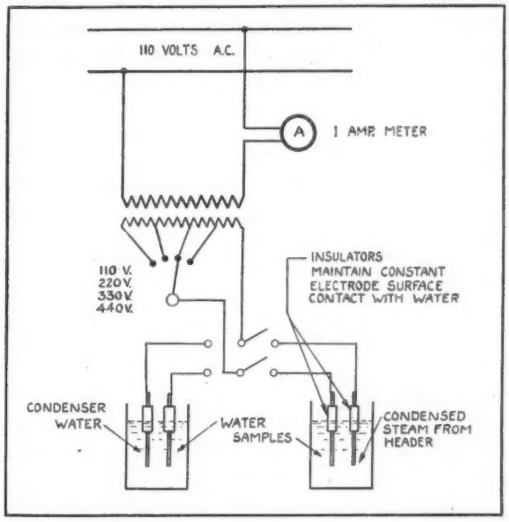


FIG. 2. CIRCUIT DIAGRAM OF WATER TESTING APPARATUS

water are of such a nature that only a small quantity is necessary to cause a relatively large increase in conductivity; it is, however, not satisfactory in those locations where the water contains elements that affect the conductivity, which are carried over by the steam, and are again absorbed by the condensate in the condenser. Such conditions are quite common in land practice where water is taken from rivers which contain organic acids or slight amounts of sewage.

Conductivity Test

For this condition, the tester shown in Fig. 1 and on the diagram, Fig. 2, has been developed, which is adaptable to all cases. This tester is a special electrical equipment consisting of a small transformer, two glass jars equipped with carbon electrodes and the proper switchboard. Current is taken from 110-v. lighting service and used to energize the primary side of the transformer. A small sensitive ammeter with a full range scale of approximately one ampere, is inserted between the transformer and the line on the primary side. From the secondary of the transformer, taps are brought out which make it possible to obtain a potential of 110, 220, 230, and 440 v. These leads from the secondary are brought out to various points on a selective switch and the jars are connected up through a double throw switch so that the electrodes of either jar can be connected to the secondary of the transformer. With this arrangement it is possible to subject the electrodes in the jar to differences of potential from 110 to 440 v. in 110-v. steps.

In order to test the condenser leakage, a sample of water is taken from the discharge of the wet pumps, and a sufficient quantity to cover the electrodes is placed in one jar. At the same time that this sample is taken from the condenser, a measured quantity of steam is condensed by means of a small copper tube condenser connected directly to the steam header. This copper tube condenser is made up of a one piece coil of copper tube so that there is no possibility of leakage of the cooling water into this sample of water which is condensed from the header. After this sample has been allowed to cool to the same temperature as the sample of condensate taken from the condenser, it is placed in the other jar of the testing apparatus. Readings on the ammeter can then be taken with the current on each jar and the conductivity of the water in each jar noted.

If leakage exists in the condenser, a greater reading will be observed on the water taken from the condenser than the water condensed from the steam header. By means of a measuring flask, small measured quantities of condenser cooling water, a sample of which was taken

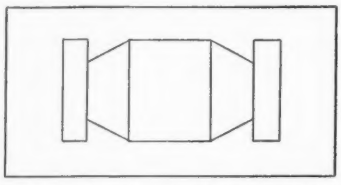


FIG. 3. RUBBER PLUG USED FOR CLEANING CONDENSER TUBES

at the same time the water was drawn from the wet pumps is added to the condensed steam from the header, thoroughly stirred and readings again taken. Cooling water in measured quantities is thus added to the steam condensed from the header until the same reading is obtained on both jars. By dividing the quantity of cooling water added to the condensed steam by the quantity of water placed in the jar, the percentage of leakage is determined. Insulators are sealed on the electrodes, as can be seen from the accompanying diagram and picture, in such a way that the addition of the water which is necessary in this test, does not affect the amount of electrode surface. It will be noted that since the ammeter is used only for an indicating instrument to show when the readings on both jars are alike, any fluctuations in voltage will not affect the results.

Installation of the ammeter on the primary side of the transformer, causes it to record the charging current on the transformer; but this is thought to be the advisable arrangement, since the ammeter readings are increased, due to the greater current in the primary winding whenever the higher voltage taps are used, making greater accuracy possible. The selective switch is used to subject the electrodes to various potentials from 110 to 440 v., which makes it possible to use this equipment with waters of widely varying degrees of purity. In cases of rather impure water, low potentials can be used which brings the ammeter reading near the center of the scale.

Another important factor in connection with condenser operations is the problem of keeping the tubes and tube sheets of the condensers clean, so as to insure a maximum heat transfer and a good flow of water through the tubes. From periodic readings, taken over frequent intervals, of the temperatures of the cooling water, inlet and outlet, the vapor in the condenser and the condensed steam, it is possible to determine quite accurately the degree of cleanliness in the condenser.

Careful records also makes it possible to determine whether this trouble is the result of decreased conductivity due to the tubes becoming slimed up or coated with mud or scale, or whether the trouble is due to the tube sheet becoming plugged with leaves or other material which may find its way past the screens, thus diminishing the quantity of cooling water. Where this latter trouble is frequent, a gage on the inlet connection of the condenser will often aid materially in determining the condition of the tube sheet by indicating an increased pressure, and it is sometimes advisable to have piping installed with the proper arrangements so that the flow of the water through the condenser can be reversed from time to time, thus permitting the water to wash off the material which has accumulated. The materials which collect on the interior of the tube surface vary, according to the cooling water, from a hard scale in a few cases, to a soft slime, and the method of cleaning must be adapted to the material which is to be removed.

Cleaning Off Soft Slime

Probably the most common method of cleaning where the trouble is due to soft mud or slime is by the use of a stiff fiber or soft wire brush. This method is effective, but requires considerable labor, is disagreeable to perform and requires that the unit be out of service for a considerable period of time. In some cases, arrangements have been made such that water jets at high pressure can be directed against the tube sheet when the unit is in service.

In cases where the material is of a soft, slimy nature, it is possible to clean the condenser quite satisfactorily by taking the unit out of service, draining the water from it and admitting steam to the condenser, at low pressure, baking the material in the tubes, after which it is flushed out by starting the circulating pumps.

Where the material collecting in the tubes is of a soft mud or slimy nature, the condenser can be cleaned quite effectually in a relatively short time by the use of plugs, blown through the tubes by compressed air. The first plugs used consisted of small disks made up of a special packing material which resembles a disk which would be cut from a thick rubber belt, these disks being made the same diameter as the internal diameter of the condenser tube. Nails were forced through the center of this cleaning disk to prevent it from turning edgewise when the air is applied to force it through the tube. This type of cleaning plug or disk is not wholly satisfactory, due to the fact that nails are sometimes blown out of the plugs if inserted with the head of the nail forward and the plug may be blown off the nail in case it is inserted with the point forward. This results in the tube becoming plugged and in a number of instances the insertion of another plug of the same type would result in the nail being driven through the wall of the tube.

For this cleaning operation a more satisfactory plug is a solid rubber affair made in the form shown in Fig. 3. These plugs have been found to wear slowly and can therefore be used over many times. Being solid rubber,

it is easy to wash the dirt from them when they are taken from the condenser after they have been used. These plugs clean the condenser tube quite satisfactorily for general purposes, even in cases where the cooling water contains some oil. This method, however, is not applicable where the deposit in the condenser tube is in the nature of a hard scale. Such conditions, however, are fortunately quite infrequent.

Auxiliary Apparatus

With the development of units of large capacity greater attention should be paid to the other condenser auxiliaries and it is now generally considered that all condensers should be equipped with duplicate circulating pumps, duplicate wet pumps and duplicate air removal equipment, since the loss of the unit even for a short time will amount to considerably more than the interest on the investment of this duplicate equipment, especially where the equipment is expected to give 24-hr. service. By the use of duplicate circulating pumps, it is possible to install them in such capacities that one pump is sufficient for the major part of the year and the second pump can be used during the warm weather conditions and in case one pump should fail, even in the summer, it would mean only a slight reduction in vacuum and would not necessitate shutting the unit down or operating non-condensing. Where the heat balance will permit, and where the electrical supply is reliable, it is the present thought that electric drive for both condensate and circulating pumps is superior to steam driven pumps. The general trend also seems to be to utilize steam jet ejectors in connection with coolers in such a way that these jets will take the air from the condenser and discharge it into a cooler which is operating at approximately 24 to 26 in. of vacuum. From this the air can be removed by means of a small reciprocating dry vacuum pump. This appears to be the most economical method of air removal at the present time. Secondary steam ejectors can be installed for emergency service so that only one reciprocating dry vacuum pump is needed. The drive for this pump, like the circulating and wet pumps, should be electric where conditions will permit.

Where the conditions are such that the temperature of the cooling water varies greatly between the summer and winter months, it is frequently possible to show a sufficient saving in pumping cost to make the additional cost of a variable speed motor drive on the circulating pumps profitable.

Detection of Causes of Corrosion

Like other types of equipment, condensers are often affected by local conditions which result in special problems which cannot be solved by ordinary methods. In one case where external corrosion of the condenser tubes was causing considerable trouble, the equipment shown in Fig. 4 was used successfully. This corrosion took place near the tube sheet in the first pass and seemed to develop only in the winter months. In order to determine the cause of this corrosion one tube at the center of the affected area was removed from the condenser and a special bushing installed in the tube hole. A pipe connection from this bushing was brought outside the water box of the condenser. A heavy glass jug containing about one pint of water, which had been doubly distilled in the laboratory, was fitted with a two-hole rubber stopper through which were inserted two glass tubes, one of which reached below the surface of the water. This glass tube was connected to the special pipe brought out from the condenser. The other glass tube was connected to a spare condenser air pump so that when the unit was put in service, vapor was drawn out of the condenser from the affected area through this special piping and caused the bubble through the pure water in the jar. The jar was then surrounded with ice so that practically no vapor would be carried out by the air pump. After the unit had been in operation for about 10 hr., the quantity of water in the jar had increased to something over a quart and showed a slightly milky condition. This water was then taken to the laboratory and tested to determine what it might contain which would affect the tubes. It was found on

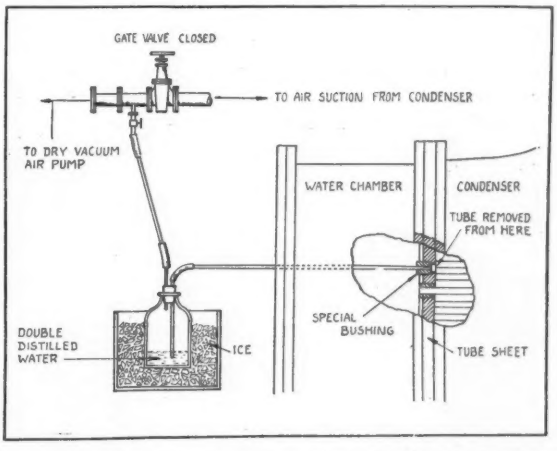


FIG. 4. EQUIPMENT USED FOR OBTAINING SAMPLES OF GASES AND VAPOR FROM CONDENSER

this test that the liquid contained free ammonia, which was probably the result of a gas works being located on the same river above the point where boiler feed water was taken for the power plant. This ammonia was being carried over with the steam and under normal operations would be removed with the air from the condenser, but during the winter months when the temperature of the cooling water was near the freezing point, these ammonia fumes were being absorbed by the water condensed on the tubes and was attacking the zinc and copper in the tubes. It would, of course, have been possible to arrange for sufficient recirculation of the cooling water in the winter months to insure a temperature which would not condense the ammonia. However, what was thought to be a better plan was adopted. This consisted in tinning those tubes on the external surface which were in the affected area, this being a satisfactory method of overcoming the trouble, since pure tin is not affected by ammonia even in high concentrations.

Decided advancement has been made in the past 15 yr. in the development of condensers and condenser equipment for operation with large units and for high vacuums. The amount of surface necessary for high vacuums has been decreased from more than 3 sq. ft. to less than 2 sq ft. per kw. in common installations and in some cases special design has made it possible to decrease this surface to less than one sq. ft. per kw.

Unusual Features in New England Hydro Plant

SURGE TANK 184 FT. HIGH AND SPILLWAY OF NOVEL DESIGN ARE FEATURES OF NEW ENGLAND POWER COMPANY'S DAVIS BRIDGE PROJECT

IF YOU desire to visualize the unusual spillway design of the Davis Bridge project which the New England Power Company has under construction on the Deerfield River in Vermont, just think of an old-fashioned phonograph horn about 160 ft. in diameter set with the small end down and connected by means of a 180-ft. vertical shaft to the bypass or diversion tunnel running under the base of the earth dam. This is one of the design features of the Davis Bridge development which is interesting because it is unusual and the surge tank 184 ft. high and 34 ft. in diameter is another engineering novelty.

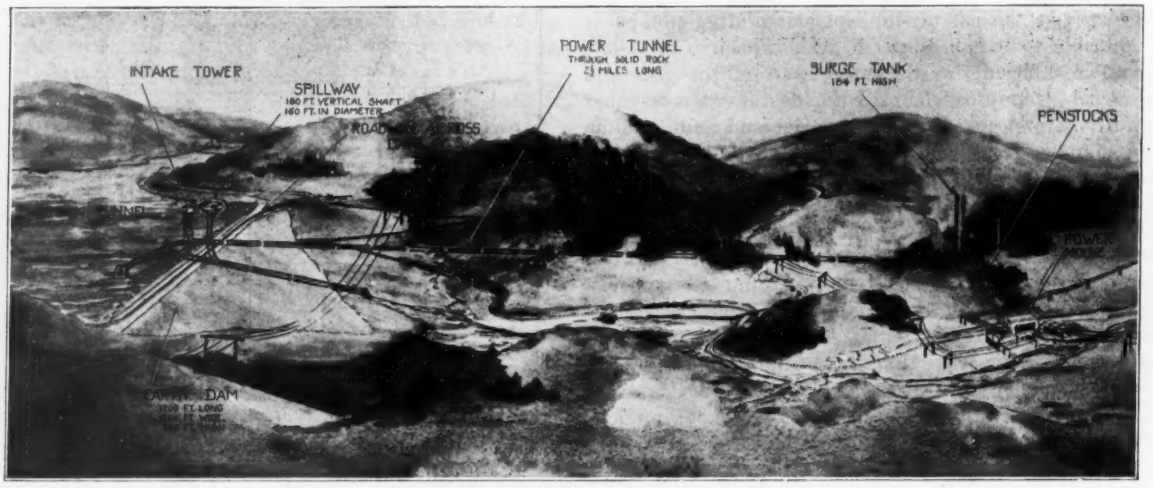


FIG. 1. ULTIMATELY THERE WILL BE THREE 20,000-HP. UNITS AT THE POWER HOUSE, TWO OF WHICH WILL MAKE UP THE INITIAL INSTALLATION

Glancing at Fig. 1, it will be noted from the artist's conception of the finished development, that an earth dam has been thrown across the valley—the valley being that of the old Deerfield River which courses its way restlessly and windingly down through the forest clad hills of old Vermont. This dam is to be 200 ft. high, about 1200 ft. wide at the base, and will extend across the valley some 1200 ft.

In order to care for the flow of the river while the dam is under construction, a concrete lined diversion tunnel equivalent to a 22½-ft. circle and 1500 ft. long has been constructed through a rock hill on the left bank of the river. From the panorama of the dam shown in Fig. 1 it can be seen how this tunnel taps the channel at right angles to the former line of flow and then curves back to the channel at a point below the dam. It is estimated that this tunnel will handle the river during floods equivalent to the maximum recorded for the Deerfield River. Work on the tunnel was begun in February of 1922 and was completed on Sept. 15.

For handling the excess water at times of high water, it was decided to use the diversion tunnel as a part of the spillway scheme. A vertical shaft was, therefore, sunk to connect with this tunnel at a point almost in line with the east end of the dam and about 350 ft. upstream. This vertical shaft was sunk during the course of the work on the diversion tunnel, since it also permitted working on the tunnel from near the middle point as well as both ends. When the spillway is completed, the upper portion of the shaft will be flared out in the shape previously mentioned, and lined with concrete. Piers of concrete will be constructed, carrying a steel bridge around the circumference from which flashboards will be operated.

Upon completion of the dam, a concrete plug will be placed above the junction of the spillway shaft and the diversion tunnel and the water will then begin to rise to the spillway level. An interesting feature in connection with the design of this spillway was the erection of a model, shown in Fig. 4, which was tested at a miniature dam built across a brook. In this way, stream flow was made to conform to actual conditions on a miniature scale, and tests were made to determine the accuracy of the calculation for capacity of the spillway.

From the map of the river shown in Fig. 3 it will be noted that the power house is to be located below Readsboro. This is about 5 mi. below the dam and in order to conduct the water to the plant it will be necessary to construct a tunnel, 2½ mi. long, through solid rock.

Work was started underground at both ends of the tunnel about Oct. 15, after approach excavation had been going on about two months. On Nov. 19 an 800-ft. adit driven into the hillside about halfway between the portals was completed, and gangs were put on, working away from the center. On May 1, the power tunnel had been driven a total of 6500 ft.

In section the tunnel is made up of a semi-circle at the top with a radius of 7 ft., with the sides carried down vertically a distance of 6 ft., giving a flat floor 14 ft. across and a cross-sectional area of 161 sq. ft. While

the rock through which the tunnel is being driven is of hard dense quality, the sides will be lined with concrete to reduce hydraulic loss.

From the tunnel intake at the dam to the outlet at the surge tank, the tunnel drops 50 ft. The mean elevation of the reservoir will be about 1350 ft. and as the normal tail elevation will be about 1000 ft., the mean operating head at the power house will be about 350 ft.

At the entrance to this tunnel will be located an intake tower 125 ft. high.

To provide for sudden changes of loads and the consequent sudden increase or decrease in the water requirements, a surge tank 34 ft. in diameter and 184 ft. high is located on the hillside just above the powerhouse. Because of the size of this surge tank, it will be possible to reduce the turbine gate opening from full load to the closed position in about 3 sec. and at the same time not build up any dangerous excess pressure in the penstocks or without the loss of any water. When the gates are so closed the water in the surge tank will rise in the surge tank until the pressure is again equalized.

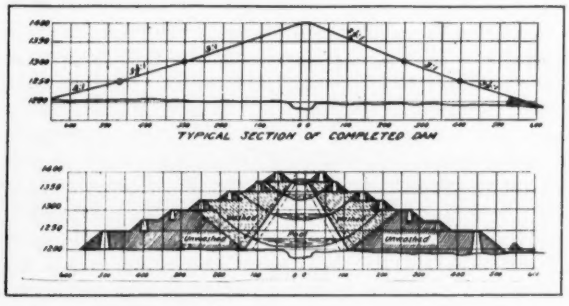


FIG. 2. CONSTRUCTION OF THE DAM IS BEING HANDLED BY THE MODIFIED HYDRAULIC FILL METHOD

Penstocks will carry the water 600 ft. from the tunnel outlet to the turbines. The surge tank connection is tapped off at the junction of the tunnel outlet and the penstocks.

Two of the three vertical water turbines of about 20,000 hp. each are being installed in the power house, which will be a brick and steel building 60 ft. by 110 ft. Since the power house will be situated about 150 ft. from the river bank, the tail race is being excavated across the intervening flat, and the material is being used to grade the outdoor transformer and switching station area.

Returning again to the dam, it will be seen from a consideration of Fig. 2 that this earth barrier is being constructed by means of a hydraulic fill. The earth is handled by steam shovels and trains. It is dumped on the up and downstream edges of the dam and then sluiced to a central pool. Thus the middle third becomes an impervious core of fine material.

About June, 1922, the work of placing fill in the upstream third was started. All the rolling stock on the job is standard gage, and the original tracks of the Hoosac Tunnel and Wilmington Railroad which run along the left bank, were utilized at first. In order to keep regular passenger and freight traffic moving and to take it off the area required for immediate construction work, a new track was built, which leaves the old route a mile below the dam site and joins it again above, traversing the construction area at a higher level.

Quoting from "Contact," the magazine of the New England Power System, the following account is given of the closing of the old channel of the river, after some 200,000 cu. yd. of earth had been placed in the dam before the completion of the diversion tunnel: "Sunday, Sept. 17, was an eventful day in the history of the project, for on that day the final gap in the river was closed and the water diverted into the tunnel.

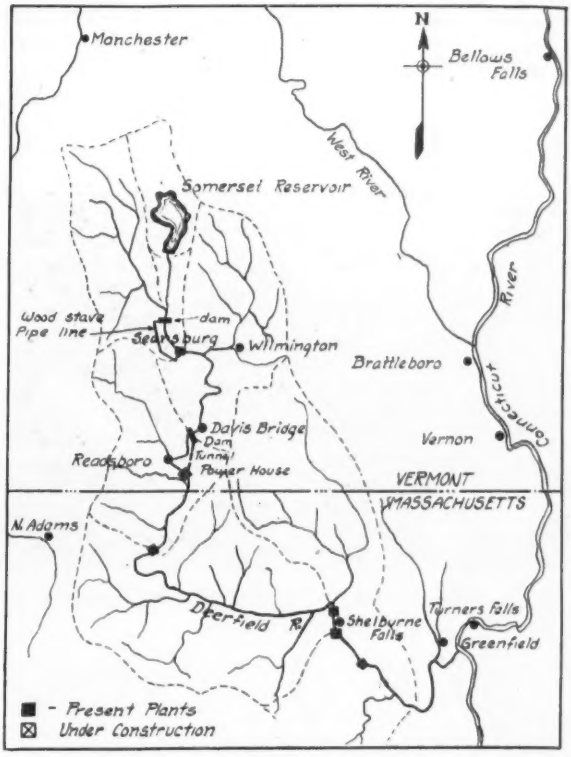


FIG. 3. PRESENT INSTALLED CAPACITY ON THE DEERFIELD RIVER IS 43,000 KW.; DAVIS BRIDGE WILL ADD 42,000 KW. AND THE ULTIMATE WILL BE 110,000 KW.

"This operation was watched with keen interest by many of the high officials of the system and by visitors, including representatives of the press. Train load after train load of earth and rock was dumped down the steep bank on the west side. Two streams of water under high pressure were directed on the material, which gradually filled up the bed of the river.

"About 200 ft. below the point where the sluicing was done, where the river bed had been partly closed, large rocks were rolled down the bank to form a small rock dam between the fill and the east bank. The fine material from the sluiced area moved down stream and collected at the rock dam, forming an effective barrier. Gradually more and more of the river water was diverted through the tunnel as the channel narrowed.

"The fascination reached its highest intensity when, as only a tiny trickle of water ran down the course of the old river bed, J. J. Baker, resident engineer of the Power Construction Co., threw an empty cement bag into the gap, placed a stone on top of it and the gap was closed. Thus was the historic old Deerfield changed from the course through which it had run for centuries."

Work of stripping the old river bed in the middle

third was now started. Good hard bottom was found about 4 ft. down. Early in October, excavation of the cutoff trench along the center line of the dam was under way. Placing of material now progressed rapidly, averaging 33,000 cu. yd. per week. At the end of the working season, there were 480,000 cu. yd. of material in the dam.

Work on the project has been carried on throughout the winter months excepting that the work on the earth dam had to be suspended from Jan. 1 to April 20 as it was impossible to carry on the sluicing process during the cold weather.

From the map of the Deerfield River, shown in Fig. 3, it will be noted that the Davis Bridge plant will be the second development below the Somerset storage dam.

FIG. 4. CAPACITY OF THE SPILLWAY WAS CHECKED BY TESTS ON A MODEL

The first plant is the 5000-kv.a. automatic station which was described in the April 15 issue of Power Plant Engineering. At present it is necessary at times to operate the Searsburg plant 24 hr. a day in order to pass sufficient water down the river to the other plants. After the Davis Bridge plant is in, it will become the key plant of the system storage since this dam will be the controlling factor for the other plants. At that time, the Searsburg plant will operate entirely automatically by control from a time clock or in accordance with the pond level at the Searsburg dam.

The ultimate development of the Deerfield will be 110,000 kw. Present installed capacity of the five plants now in operation is 43,000 kw. and the Davis Bridge plant will add 42,000 kw. to the total.

In the preparation of this article, we are indebted to A. C. Eaton, hydraulic engineer, and C. R. Bliss, office engineer, of the Power Construction Co., which handles the engineering and construction work of the New England Power System.

Pride Needs Direction

By Jack L. Ball

I OVERHEARD an engineer, a very neat appearing chap, speak of so-and-so as being the most untidy fellow who ever had charge of a power plant. The speaker and the man he criticized are in charge of medium sized, modern industrial power houses and by a strange coincidence, the equipment from overfeed stokers to four-valve engines are nearly duplicates.

I know, of course, that many engineers are not very particular about their personal appearance when they are at their work. Many things govern this; the most important is that they haven't time to be continually fussing with a bar of soap and a towel. Other and more important things occupy their time.

Cleanliness in all things is a virtue, but cleanliness in itself does not indicate one man's superiority over another, nor is it a sure sign of an efficient power plant. It does, however, indicate that someone connected therewith has a touch of pride, is at least interested in a way even though the vital element that enters into the successful operation of a plant lies hidden.

Not many years ago, I was familiar with a plant that was connected with a large factory. If I remember rightly, the engine was a Corliss of about 450 hp. and the two boilers, of the vertical water-tube type, were about 250 hp. each. The engine room put one in mind of a miniature botanical garden and the boiler room ran a close second. Without exaggeration, those plants and flowers received more care than the plant equipment. The head of the company took pride in this layout, more so than in getting his power cheaply. Anyhow, the management changed and on a visit to the factory not long ago I noticed that the central station was furnishing power for individual motors on stamp machines, presses and other equipment of like nature connected therewith.

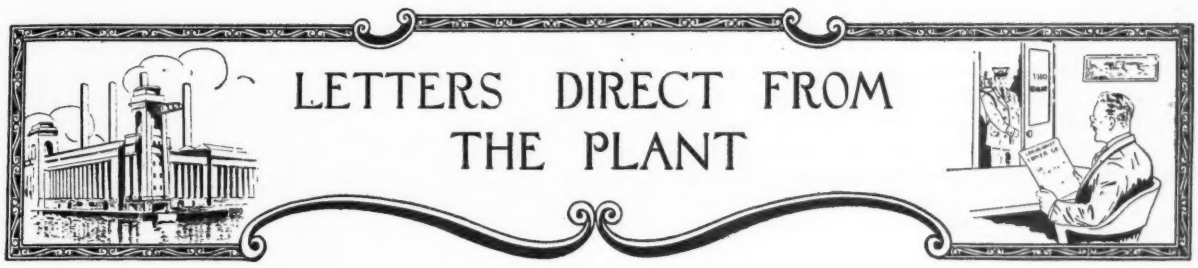
Although the preceding illustrates an extreme case, the fact remains that a man in charge of a power house can't be in possession of first-hand information about his plant and not soil his hands or his clothing. He could, of course, leave all the inspection details to his subordinates; but there aren't many of us who would care to work for a man of that kind with such an important trust or responsibility resting on our shoulders, even though we might appreciate the confidence bestowed.

A clean, smooth-running and economical plant is something of which to be proud. The men who are responsible for a condition of this kind are in possession of something greater, however, and that is their ability, the knowing what and how to do.

I had occasion to visit a central station not long ago where the chief engineer, a young man about 35 yr. of age, is an acquaintance. Inquiring as to his whereabouts, I was informed by the watch engineer that I'd probably find him in the boiler room. When he crawled out through a cleanout door, I did not recognize him until he spoke. He was completely covered with soot and fireclay.

"That last arch and furnace lining didn't last at all," he began. "I depended on the masons to do this work as it should be done instead of being right on the job myself, at least part of the time. The bricklayers didn't put the binder in right and you know that a firebrick lining is just as strong as the binder that holds it together. It'll take me a week to get clean, but I know that we won't have any firebrick trouble in that furnace for a while at least."

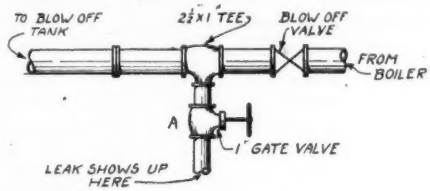
There are many of us who would welcome a job where dirt and grime are unknown; but where an engineer is almost everything from a lathe hand to a boiler maker, he is too busy most of the time to keep spotlessly clean. Pride of a certain kind is all right within certain limits, but real pride is knowing our plants and being able to keep them operating in an economical manner.



Scheme for Detecting Leaky Blowoff Valves

As illustrated on page 493 of the May 1 Power Plant Engineering, the scheme for detecting blowoff-valve leaks can be improved upon by making some simple and inexpensive additions. Should the operator neglect to close valve A before opening the blowoff valve, considerable damage or discomfort could be caused, depending upon where the discharge occurred.

This damage can be overcome by screwing a nipple with a 90-deg. elbow attached, into the valve. Into the other end of the elbow, screw another nipple and a check valve, the check being upside down with the regular discharge side next to the elbow. Any leak in the



ARRANGEMENT OF BLOWOFF PIPING AND VALVES TO DETECT LEAKS

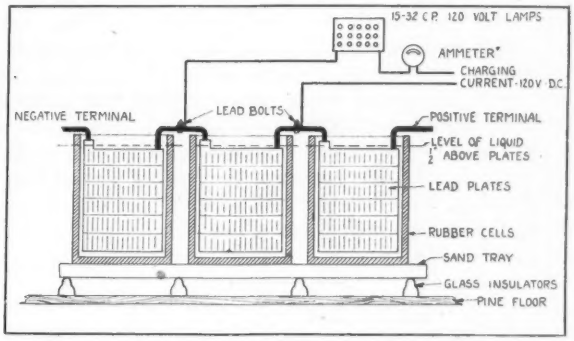
blowoff valve will show at the check valve. Should the blowoff be opened with valve A also open, the rush of water will lift the disc of the check and hold the valve shut until the blowoff valve is closed.

By installing the tee shown in the illustration with the center opening up instead of down, and screwing a nipple with an upright check-valve attached, into the tee, the same idea can be used, the check being attached wrong end on as in the other case. Valve A can be used above or below the check as desired. No matter how small the leak is at the blowoff valve, steam will show at the top opening, as there is always a clear opening down to the discharge pipe. It is obvious that valve A should always be left open; in fact, this valve could be dispensed with altogether if either arrangement is adopted.

Toronto, Ont. James E. Noble.

Care of Storage Batteries

Successful operation of a storage battery requires as much attention from the engineer as any other piece of apparatus about the plant. It should be inspected on each watch for grounds or short-circuits caused by buckled plates, or sediment in bottom of cells touching both positive and negative plates. The distilled water should always cover the plates ½ in. It is well to keep a small pitcher handy for that purpose. The battery-room must be clean, dry and well ventilated. The cells should be set in sand trays supported on earthen or glass insulators, on a pine floor, laid above a well-drained concrete floor. Care should be taken not to allow the cells to become flooded and overflow onto the floor, which might cause a ground. The outside of the cells should be kept clean and dry at all times. A thin strip



ARRANGEMENT FOR CHARGING SEPARATE CELLS IN A BATTERY

of hard wood should be kept handy to use in cleaning lead-sulphite from between the plates. A flat "bung-hole" lamp having a long glass stem may be purchased; this attached to a long flexible wire will enable the operator to make a thorough inspection of plates and the whole interior of the cells.

With the best of care, the battery elements will eventually fail to perform their duty, and then, if the operator is not familiar with the manipulation of the apparatus, he may be puzzled to know what to do next. With his portable voltmeter he may test each cell—after charging. If one or more cells give a low reading, they should be charged separately. This may be done by disconnecting the terminals of the battery and drilling holes in the terminals of the low cells and connecting the charging circuit with lead bolts, as shown in the accompanying sketch, being sure to have the correct polarity. For a 120-v. circuit, fifteen 32-c.p. lamps in parallel will furnish about the right amount of resistance for charging. Four or five hours charge will probably bring the voltage up to normal, when it may be put in service again. Particular attention should also be paid to the specific gravity. On each watch, the cells should be carefully gone over with the hydrometer. If the reading is below 1.195, other conditions being normal, electrolyte of 1.120 may be added to the cell, before the charging.

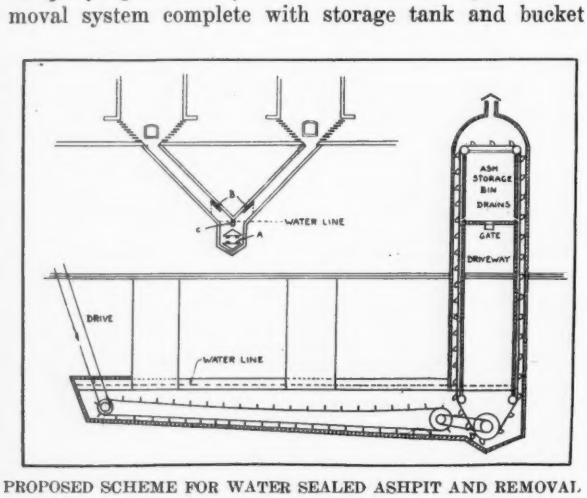
Several years ago, I had charge of a plant in an office building in New York City. Part of the equipment consisted of an 8-hr., 80-amp. storage battery, composed of 62 cells. The battery had not been giving satisfactory service for some time previous to my taking

charge. The practice was to start the generator in the morning with the battery on charge. As soon as it was fully charged, the generator would be shut down and the lights in the building were served by the battery for the remainder of the day. On inspection it was apparent that an overhauling was necessary, accordingly the battery company was notified and a crew of three men were soon on the job. As the connections between cells were solid, they had to be cut. Before the job was started, all tools and materials necessary for the work, new plates, separators, etc., were provided so that there might be no delay. As the plates were removed and cleaned, they were hung in a large tub of distilled water. Many were discarded as unfit for use. The cells were washed and scrubbed, a new electrolyte was made of sulphuric acid and distilled water 1 to 3, stirring it with a wooden paddle, bringing the specific gravity to 1.210. In the meantime the plates were being replaced in the cells, and the terminals connected by lead-burning. When the electrolyte had been replaced and all connections made, the battery was put on charge. After 27 hr., when the cells were all gassing freely, the charging was stopped and the cells were allowed to cool. A reading was soon taken and all cells showed a specific gravity of between 1.208 and 1.212. The action of the battery was entirely satisfactory, and for the following 3 yr. that I was there, the battery was never out of service for repairs.

Camden, Me. M. M. BROWN.

Water Sealed Ash Pit

IN THE Jan. 15 issue of Power Plant Engineering, on page 121, I noticed a novel design of a water sealed ash pit for stoker furnaces. I have shown in the accompanying sketch my idea of such an ash pit and removal system complete with storage tank and bucket



PROPOSED SCHEME FOR WATER SEALED ASHPIT AND REMOVAL SYSTEM

elevator. It should be rigged up to operate at moderate speed and be driven by one motor. The pit itself has a V-shaped bottom and has a fall toward the sump or well wherein the elevator operates.

This bucket elevator is carried over the top of storage bin through concrete tubes which can be built integral with the bin and bin supports above the ground line.

Drains are provided in the bottom of ash bin to allow water carried up to drip back through the vertical shaft. A double cable flight conveyor with flights as shown at A′ made of steel and perforated somewhat, would drag the cinders to pit D from which the buckets would carry them up through the right-hand shaft, dumping into open top of bin.

The seal is shown at C, the intensity of which can be regulated by the water level. Means should be provided for drawing this pit and sump quickly, and for the introduction of air for ventilation in case of a hurry-up repair being required.

Auxiliary gates at B could be closed when a breakdown occurred and the storage space above these gates would allow the stokers to run for some time. In the larger plants it would probably be best to have each third or fourth of the boiler capacity served by a separate unit.

Culver, Ind. J. M. SULLIVAN.

Determining Phase Rotation

ON PAGE 424 of the April 15 issue, F. C. DeWeese has an article, "Phasing Out Alternators and Parallel Operation." In this article Mr. DeWeese has endeavored to show phase rotation by indicating the instantaneous direction of current. This in itself, however, will not indicate phase rotation.

Let us assume in diagram A, Fig. 5, which is reproduced here, that the motor will run clockwise as the

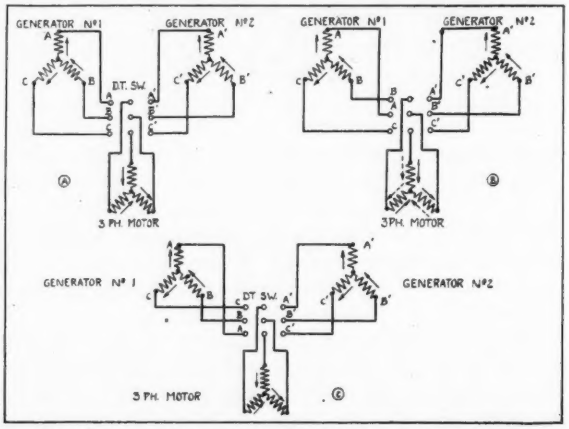


DIAGRAM SHOWING PHASE ROTATION WITH DIFFERENT CONNECTIONS

connections are shown regardless of which generator the motor is connected to.

This will indicate that generators one and two are in phase. Now it is stated in the article that generator one and two, diagram C, is also in phase; but is it?

The leads A and C of generator one have been transposed in diagram C from what they were in diagram A, therefore the motor will run counter clockwise when connected to generator one.

If connected to generator two, diagram C, it will run clockwise, as no changes in the leads were made from what they were in diagram A. This reversal of rotation shows the generators in diagram C to be out of phase although it is to be noted that the instantaneous direction of current through the motor winding in either diagram A or C is the same. Magnetic rotation in the motor is due first to the proper location of the three windings which are indicated correctly throughout Fig. 5 and

second to the relative time of the maximum and zero current in the three windings of the motor.

This magnetic rotation is equivalent to the same thing as phase rotation and is indicated by the direction of rotation of the motor's rotor.

Ft. Dodge, Ia. CLAUDE D. MARTIN.

I welcome Mr. Martin's criticism, for it gives me an added opportunity to explain further some points in connection with phasing out alternators with a three-phase motor that possibly were not made clear in the article.

In the first paragraph of Mr. Martin's letter, the statement is made, "Mr. DeWeese has endeavored to show phase rotation by indicating the instantaneous direction of current. This in itself will not indicate phase rotation." Mr. Martin, supposedly, holds to the opinion that "current" and "magnetic field" are two separate and distinct properties as far as one bears any relation to the other, when, in fact, the magnetic field cannot exist without the flow of current. The magnetic field of an induction motor is set up by the flow of current in the windings, and the direction of rotation of this magnetic field, or in other words, the phase rotation, is dependent upon the instantaneous direction of the current. For example: assume a generator connected to a motor. As long as the connections remain unchanged, the instantaneous direction of the current in the generator windings and motor windings will be in the same relative direction, the rotating magnetic field will be in the same relative direction and the motor will continue to rotate in the same direction. Now if we interchange any two of the leads to the motor, the instantaneous direction of the current in two of the phase windings of the motor will be reversed from that of the former connection (refer to diagram B), the phase rotation will be reversed and the direction of rotation will be reversed. If we again interchange any two of the generator leads to the motor, regardless of whether they are the same as were interchanged before, the instantaneous direction of the current will be the same as at first, and the direction of rotation of the motor will be the same as with the first connection.

If we should have had two generators connected through a double-throw switch to the motor, and the machines were in phase with the connections as at first made, they would be out of phase with the second connection and would again be in phase with the third connection, and as stated before, regardless of whether the leads were connected to the motor in the same relative positions as at first.

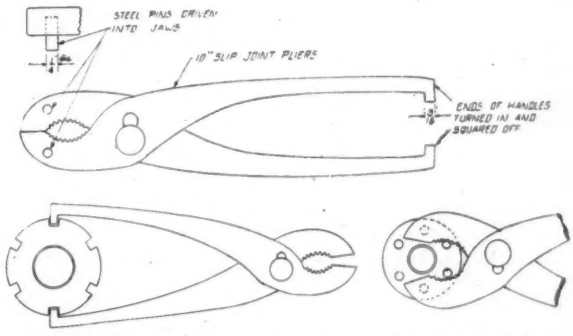
It should always be kept in mind that as far as the winding in the generator or motor is concerned, there is no particular phase which is phase A, as all the phases are identical. Hence when you have two machines with leads arbitrarily marked A, B and C, it is not at all necessary that A of one machine should be connected to A of the other machine. For synchronizing, the only thing that is necessary is that the phase rotation shall be the same for the two machines, assuming, of course, that the voltages are approximately the same and the machines are in step. If the phase rotation happens to be different in the two machines, it will only be necessary to interchange any two leads of one of the machines to bring them in phase. Opposite phase rotation will be indicated by opposite direction of the motor, when switched from one machine to the other.

This is a safe and entirely satisfactory method of testing for correct phase rotation, for if the motor rotates in the same direction when connected to either machine, you may be absolutely sure of your ground. I trust that the foregoing simple line of reasoning will serve to make the matter clear. The ease and simplicity of this method should be more thoroughly understood to be appreciated, as to my mind it is one of the most satisfactory methods of phasing out machines.

Pine City, Minn. F. C. DEWEESE.

Pliers Made Into Adjustable Spanner Wrench

HEREWITH is illustrated a simple adaptation of a heavy pair of pliers to spanner wrench purposes, without interfering with the usual cutting and gripping action of the tool. The feature which is of most importance,



ADAPTATION OF PLIERS AS AN ADJUSTABLE SPANNER WRENCH

is that the plier is a tool which is most frequently at hand and where this embodies spanning lips, which are adjustable through the action of the hinge between the handles, a most serviceable means of quickly turning any nut, bearing or other screwed part, the rim or face of which is provided with spanner slots or holes.

As are shown in the sketch, the alteration of the pliers consists of two driven fitted pins, one in each jaw of the tool. The handle ends are turned in and squared up to provide the gripping edges for spanner slots in the face of any screwed piece. The diameter of the pins is for normal use, ¼ in., and the width of the handled edges about 3/16 in., for average use, however, any particular line of machinery on which this tool may be used will have various sizes to which it may be advisable to fit corresponding gripping edges. The use of this tool is far more rapid and workmanlike then the use of the usual punch and hammer.

Washington, D. C. G. A. LUERS.

Economical Steaming Secured at Partial Loads

IN THE article of the above title, which appeared on page 525 of the May 15th issue, reference was made to a number of steel wind boxes or air zoning boxes by which the air to the fuel bed could be definitely controlled.

These boxes, we have since learned, are of special design and construction and were built by and under the patents of C. L. C. Magee Co., Inc., of Chicago.

PROBLEMS IN OPERATING POWER EQUIPMENT

What Is the Cause of This Pound?

In the cylinder of one of two engines which we recently installed, there is a sharp metallic click at the crank end of the stroke. At times this noise is scarcely noticeable, but becomes quite audible when the load comes on. These engines are of the four-valve, double eccentric, piston valve type; 15 by 36 in., 105 r.p.m. What is the cause of and remedy for this noise?

On this same engine, the flywheel runs slightly out of true sidewise; that is, when looking at the face of the wheel it appears to move from side to side. On the other engine, the wheel is slightly out of round. On which of these engines does the most strain come?

What is the best remedy for end play of a crank shaft, and does this play place a strain on the crosshead?

H. B.

Checking Up on Combustion

If the volumetric analysis of a sample of flue gas is CO_2, 15 per cent; CO, 0.6 per cent; O_2, 5.1 per cent; and N_2, 79.3 per cent, what are the percentages on a weight basis?

2. If an analysis by weight gives CO_2, 17 per cent; CO, 1.2 per cent; O_2, 7.0 per cent; and N_2 74.8 per cent, what would be the volumetric analysis?

3. In burning a pound of carbon in a furnace, using 20 lb. of air per pound of carbon, how many pounds of CO_2 would go up the stack? How much oxygen and nitrogen would there be?

If the temperature of the flue gases is 500 deg. F., how much heat would be lost and what would be the percentage of fuel lost if the heating value of the carbon is taken as 14,544 B.t.u. and the specific heat of the gases is 0.2634?

4. What will be the temperature of the products of combustion if the fuel has a heating value of 14,544 B.t.u. per lb. and the weight of the gases of combustion is 19 lb. per lb. of fuel? The specific heat of the flue gas is 0.2634 and the temperature of the air entering the furnace is 70 deg. F.

5. Suppose that the fuel is carbon and that combustion is complete, what would be the percentage of CO_2 by volume if the air excess is 110 per cent?

6. If a boiler feed water contains 46 grains of incrusting solids per gallon, how many pounds of scale will be formed in a 24-hr. run for a 250-hp. boiler operating at rating, allowing 34.5 lb. of water per horsepower-hour?

V. N.

A. The volumetric analysis of any mixture of gases may be changed to an analysis on a weight basis by multiplying the volume percentage of each constituent by the molecular weight of that constituent; these products for each item are then summed and each is then divided by the sum to give the percentage by weight. Thus we have the following:

Gas	Per cent Volume		Molecular Weight		Product	Percent Weight
CO_2	15.0	×	44	=	660	21.4
CO	0.6	×	56	=	33.6	1.085
O_2	5.1	×	32	=	176	5.7
N_2	79.3	×	28	=	2220	71.8
					Sum 3089.6	Total 99.985

2. A change may be made in the other direction by first dividing the percent by weight by the molecular weight, and then dividing this quotient by the sum of similar quotients to give percent by volume. The process is as follows:

Gas	Wt.		Mol. Wt.		Percent Wt., Mol. Wt.	Percent Volume
CO_2	17	÷	44	=	0.3860	11.700
CO	1.2	÷	56	=	0.0212	0.645
O_2	7	÷	32	=	0.2190	6.660
N_2	74.8	÷	28	=	2.6700	81.100
					Sum 3.2962	Total 100.105

In these examples the figures 44, 56, 32 and 28 are the molecular weights respectively of CO_2, CO, O_2 and N_2.

3. In burning one pound of carbon, completely, a fixed quantity of CO_2 is formed regardless of the excess amount of air which may be supplied for combustion. Twelve parts by weight of carbon unite with 32 parts of oxygen to form 44 parts of CO_2. Thus, if we burn one pound of carbon there will be formed $44 \div 12 \times 1 = 3.67$ lb. of CO_2, and $32 \div 12 \times 1 = 2.67$ lb. oxygen will be used. If 20 lb. of air is used to effect this combustion, there will be supplied 76.8 per cent of 20 = 15.36 lb. of nitrogen and 23.2 per cent of 20 or 4.64 lb. of oxygen. As 2.67 lb. of this oxygen is used for combustion, there will remain 1.97 lb. of oxygen in the flue gases. An analysis of the flue gases will then show CO_2 3.67 lb., O_2 1.97 lb., N_2 15.36 lb., totaling 21.00 lb. If this flue gas is raised in temperature from 70 to 500 deg. or through a range of 430 deg. the heat added will be $21 \times 430 \times .263$ (specific heat of the flue gases) = 2410 B.t.u. As the heating value of the carbon is 14,544 B.t.u., the percent heat loss in the flue gases will be $2410 \div 14{,}544 = 16.6$ per cent.

4. If the weight of the gases of combustion or one lb. of carbon is 19 lb., the heat required to raise this gas through one deg. F. will be $19 \times .263$ = approximately 5 B.t.u. As there are 14,544 B.t.u. available, the rise in temperature through the furnace will be $14{,}544 \div 5 =$ 2910 deg. and as the initial air temperature was 70 deg. the final temperature will be 2980 deg. F.

5. As stated in question 3, one lb. of carbon combines with 2.67 lb. of oxygen to form 3.67 lb. of CO_2.

To supply this quantity of oxygen there will be required $2.67 \div 2.3 = 11.5$ lb. of air and as there is 110 per cent excess, the total will be $11.5 \times 2.10 = 24.2$ lb. of air forming 25.2 lb. of flue gas.

An analysis of the flue gas would give CO_2 3.67 lb., O_2 2.94 lb., and N_2 19.3 lb. The percentage analysis by weight would then be CO_2-14.6, O_2-11.65, and N_2-73.75. This analysis can be changed into a volumetric analysis as in question 2 as follows:

Gas	Per-cent Weight		Molecular Weight	Quotient	Percent Volume
CO_2	14.6	÷	44	0.332	9.97
O_2	11.65	÷	32	0.364	10.9
N_2	73.75	÷	28	2.640	79.2
				Sum 3,336	Total 100.07

6. If a boiler evaporates 34.5 lb. of water per hp.-hr., then if it develops 250 hp. for a period of 24 hr., the total water evaporated will be $34.5 \times 250 \times 24 = 207{,}000$ lb. or about 24.800 gal. As there are 46 grains of incrusting solids in one gal. of feed water, the total solids precipitated in the boiler will be $46 \times 24{,}800 = 1{,}140{,}000$ grains, or as there are 7000 grains in a lb,. 163 lb. per 24 hr.

Causes of High Steam Consumption

In the April 15 issue, on page 444, I noticed the question asked by M. P., "What causes the high steam consumption in a uniflow engine?" I cannot quite see how a dirty steam separator would cause it unless it was so dirty as to stop the flow of steam and act as a steam pressure reducer and so reduce the pressure at the throttle below the point called for in the guarantee. I do not know from which side of the steam separator he takes his steam consumption; if it is taken before passing through separator, his trap on it may be at fault. It may be possible that his turbine blades are filled up with dirt and scale and need cleaning. He may have too much clearance around the ends of blades or his steam nozzles may be cut out. Another thing that would cause a waste of steam would be his overload valve leaking when the turbine is running at normal full load.

All of these things, I think, would tend to cut down the efficiency of his turbine for if he is showing 15 to 20 lb. more steam per kw.-hr. than the makers guarantee, he certainly is wasting steam enough to run a 625-kv.a. condensing turbine with 29-in. vacuum.

Southington, Conn. George A. Hubbard.

Determining Motor Temperature

I am desirous of knowing the exact location in which to place Centigrade thermometers on a motor in order to obtain the correct temperature reading. Also, what temperature should the thermometers register when placed on a 50-deg. motor? If the motor was running at normal temperature, how much above the surrounding temperature should this temperature be?

R. E. C.

A. The exact location in which to place a thermometer in determining the operating temperature of a motor, depends to a great extent upon the type and construction of the machine. Motors, in general, vary considerably in shape, methods of cooling, protection against water or dust, mechanical strength, etc., and these factors, of course, will all have an influence upon the temperature distribution of the machine.

Any large machine requiring a considerable amount of floor space should have the room temperature taken at four different points nearby, and at a sufficient distance away from the machine to be unaffected by heat from the latter. Two thermometers, one in air and one in a specially designed metal cup containing oil, are used at each point to measure the room temperature. Before starting the heat test, thermometers should be placed on all important accessible stationary parts, such as the series and shunt field spools, pole tips, frame, etc., in case of direct current machines. In addition, thermometers should be placed between pole tips to register the temperature of the air thrown off from the surface of the armature and from the air ducts. Each thermometer should be attached with the bulb in contact with the part of which the temperature is required, the bulbs being covered with putty or a wad of tape. Thermometers which are to register the temperature of air ducts should be so placed that the bulb cannot make contact with the iron laminations while the machine is running.

During the test, the machine should be shielded from currents of air coming from adjacent pulleys and belts. Unreliable temperatures are obtained when the machine is located so that another machine blows air upon it. A very slight air current will cause great discrepancies in heating; consequently either a canvas screen should be used to shield the machine under test or the machine causing the draft should be shut down.

The foregoing, of course, refers mainly to large motors. In the case of small units, however, one or two thermometers placed in contact with the field coils or the frame of the machine will be sufficient. A few trials will usually show up the hottest parts of the machine.

According to the A. I. E. E. Standards, the standard ambient temperature of reference for air is adopted as 40 deg. C. This means that the thermometer on a 50-deg. machine must register not higher than 40 + 50 or 90 deg. C. Even if the room temperature is below 40 deg. C., however, the allowable rise of 50 deg. C. must not be exceeded.

Ice-Making Tank Construction

On page 445 of the April 15 issue of Power Plant Engineering, C. D. asks for information as to how to construct an ice tank. I am of the opinion that the plans submitted in the answer will not prove suitable for present day practice and will give trouble. I have seen too many tanks of this design fail. I would suggest that C. D. build a slab of concrete 6 or 8 in. thick, according to the foundation or ground he has to build on, 12 in. larger than the tank on all sides, put 4 in. of cork board on top of the concrete, put down in hot pitch with at least ½ in. of pitch on top of cork, paint this tank with good red lead and boiled linseed oil, put it on his cork and concrete foundation; then build a good substantial board wall all around his tank at least 10 in. from it and fill the space with granulated cork. He will then have a tank that will last as long as the rest of the plant and be as efficient the last year as the first.

New Orleans, La. J. H. Lamar.

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N. E. L. A. Helps Solve Changing Central Station Problems

Any business which goes through a period of rapid expansion is naturally confronted with new and changing problems due to that growth. Methods and, in fact, entire viewpoints must be changed to keep pace with the scope of development. The procedures of business may be likened to the clothes of a growing boy; they must be frequently renewed if they are not to be outgrown.

It is through this stage that public utilities dealing with the production and distribution of electrical energy have come during the past two decades. The growth has been phenomenal and naturally problems have become more complex. Fortunately, however, the central station industry has been headed by men of vision; men who could meet the conditions with new and broad policies of administration.

In the early days, production of energy and its distribution was the big problem; how to build plants and lines which would give uninterrupted service. Efficiency was secondary. Then as this problem was met successfully, refinements were introduced and entire plants were scrapped by bold managements because of the development in new equipment by which power could be produced with reliability and at less cost.

Then with the production problem out of the way for the time being, came the question of selling the product. Salesmanship came in as a big factor and this was solved with varying degrees of success. Then the question of public opinion began to assert itself. Politicians began to look upon the utilities as excellent material for political capital. Fortunately, again, the men in the industry appreciated the new viewpoint in time to act. Public relations became the problem of the hour. That problem is today being solved in an effective way.

One of the contributing causes for the fact that central station men have been able to keep up to the requirements of their growth has been in the work of the National Electric Light Association. It has been their forum where big problems could be discussed and experiences compared.

Beginning on June 4, this organization will hold its forty-sixth convention, this time in New York City. The sessions will be as broad as the industry itself, for each phase of the work will have its place. In the technical section sessions, those problems of production and distribution will be taken up.

All power plant engineers will be interested because the production of power is a business which can no longer be defined by the limits of any organization with which it may be attached.

Piping and Fittings for 1200-Lb. Pressure

Standards for power plant equipment which served their purpose for the pressures of yesterday are inadequate for the pressures contemplated today; the change is startling in its abruptness. Accessories designed for 600 lb. pressure will have to be re-designed for a demand which now calls for a steam pressure of 1200 lb.

Manufacturers are confronted not only by the design problem of pressure but also by the problem of

temperature effects upon various metals. In fact it is this latter effect which is causing the greater concern, for once the physical characteristics of a metal are known at high temperature the matter of thickness or weight of metal to withstand a given pressure may be readily determined.

With rapid development, there is apt to result a confusion due to lack of standardization. This works a hardship upon the designer in selecting equipment, upon the manufacturer because of high production costs, and upon the operating man because he must live with the installation, for the life of the various pieces of equipment.

In this issue Mr. Skeen sets forth certain facts which have a definite bearing upon this important question of standardization. He also presents information which will prove invaluable to anyone making an investigation of high pressure piping and fittings either for the purpose of personal information or for design.

Economizer Troubles Overcome

It has been but a short time since economizers were thought of with skepticism by many engineers. Troubles of corrosion and maintenance were oftentimes perplexing and it has required a great amount of practical experimentation by many engineers to solve these problems.

Co-operation among these engineers has been a great factor towards increasing the use of economizers; in fact, the dissemination of engineering experience and knowledge forms the basis upon which most of the present-day construction and operating achievements are based.

No longer is there any hesitancy concerning the installation, operation and maintenance of not only the cast-iron tube economizer, but also the steel section economizer; they have both come into wide use, and are universally recognized as essential where full power plant economy is to be practiced and realized.

In this issue H. M. Guilbert furthers this spirit of co-operation and advancement by presenting a valuable article on the care and operation of fuel economizers.

Careless Use of Tools Invites Criticism

It can truthfully be said of the vast majority of engineers that a sense of pride prompts them to keep the equipment within their charge in first class operating condition. Indicator cards will show that they appreciate the full value of properly set valves; a survey of engine rooms will not reveal any steam leaks; in fact, from all general appearances everything is well kept up.

There are, however, many details which in themselves may not impair the efficiency of a unit, but will show how far an engineer's true pride really goes. Have you ever walked into an engine room and noticed that the cylinder head nuts of a fine looking engine had been tightened with a cold chisel, that the marks of the chisel were plainly visible? When you do see this, it certainly detracts from your first impression of both the engineer and his plant; you feel that he is careless either in his own detail work or he is not following closely enough the work of his assistants.

If you nose around a little further in this plant you will no doubt find where pipe wrenches have left their "bite" on pump rods, where valve bonnet bolts have been taken up with that same pipe wrench, the marks are there as evidence. This same plant will no doubt show plenty of evidence that gas pliers have been used on many a small bolt or machine screw. Now you pass another engine cylinder head, the nuts are not marred in this case but you do notice that with just a little effort the engineer could have turned all the nuts so that they would have a symmetrical appearance.

This may be going after the little things but they all count, not alone because of the criticism of other engineers but also because of the "big boss," who although he may not be an engineer, has a keen eye for what will appear to him as abuse of his equipment. A little thought on this subject will convince you that an opinion as to your ability and worth may be based upon some of the little things you do about the plant.

Control for Power Station Auxiliaries

In visiting a large power station the thing that usually is most interesting to the layman is the mammoth 20,000 or 35,000 or 45,000-kw. turbo-generator, as the case may be. This machine, because of its sheer vastness, impresses him, and during his entire stay in the plant it is the center of attraction for him. The auxiliaries which are scattered about throughout the plant do not strike him as being of particular importance alongside the main units.

An engineer, operating or designing, visiting the same plants views it in an entirely different manner. He accepts the main generating units as a matter of course and while they are no less impressive to him than to the layman, he is far more interested in the arrangement and types of auxiliaries used and in their method of control. He knows that the large turbine is absolutely dependent upon the auxiliaries for its operation and that the continuous operation of the plant is governed by the operation of the auxiliaries. He knows that most of the trouble and maintenance expense is due to the auxiliaries and that most of the preventable losses in the turbine occur in connection with auxiliary equipment.

The operating engineer can do little towards increasing the efficiency of the main units. His entire means of control over the efficiency of the plants is in connection with the operation of the auxiliaries.

In any plant, therefore, the auxiliary equipment and its arrangement is the most important part of the plant. It follows then that the method of controlling these auxiliaries is also of extreme importance, and in the installation of auxiliaries care must be exercised in selecting correct control equipment.

As the size of plants increases, this control of auxiliaries becomes an increasingly important problem. In these plants many of the electrically driven auxiliaries are controlled from distant points and in addition to the usual starting and speed control equipment, remote control devices have to be provided.

It is evident, therefore, that the question of control of auxiliaries is not a small matter in modern power plant design, and the article on this subject by A. L. Harvey which appears in this issue should be of considerable interest to power plant engineers.

Many Features in Design of New Taylor Stoker

NEW TYPE H STOKER EQUIPPED WITH CRANK SHAFT OR HYDRAULIC DRIVE; ENCLOSED SPUR GEAR DRIVE FOR CRANK SHAFT; BOTTOM OF RETORT FORMED BY TELESCOPIC AUXILIARY PUSHERS

SINCE the American Engineering Co., of Philadelphia, first introduced the multiple-retort underfeed stoker some 18 yr. ago, it has made many developments in the design of these stokers. In order to combine them all in one harmonious whole, it has produced the type "H" Taylor stoker which embodies also a number of interesting new features that are claimed to set a new standard of combustion performance.

When the Taylor stoker was first introduced, a fuel burning rate of 750 lb. of coal per retort per hour met practically all requirements of central station and industrial practice. The rapid increase in draft at the boiler breeching and the increase in rates at which the heating surfaces are worked, has made higher burning rates necessary. As a result, the new stoker has been designed to burn efficiently in excess of 3000 lb. of coal per retort per hour.

In addition to the increased capacity, the stoker design has been improved along lines indicated by the new requirements. By constructing the bottom of the retort of auxiliary pushers, telescopic in action, the relative stroke between each of which can be varied, it is possible to meet any feeding conditions the particular fuel characteristics demand. Such construction also facilitates the cleaning out of non-combustible matter, as formed, from every portion of the retort. The crank shaft drive has been improved in efficiency and durability by using a spur gear power box, completely enclosing the drive, eliminating all clutches and introducing additional protection for the driving mechanism from foreign matter in the fuel. Hydraulic drive can also be furnished for special applications.

Auxiliary pushers are driven from the feeding plunger by means of one rod with one adjustment for each retort. These pushers are telescoping in action inside of the furnace and their relative stroke one to the other can be adjusted so as to feed to each part of the retort all of the fuel that can be properly burned at that point with the amount of air supplied to it. This design of pusher eliminates the sticking which has existed

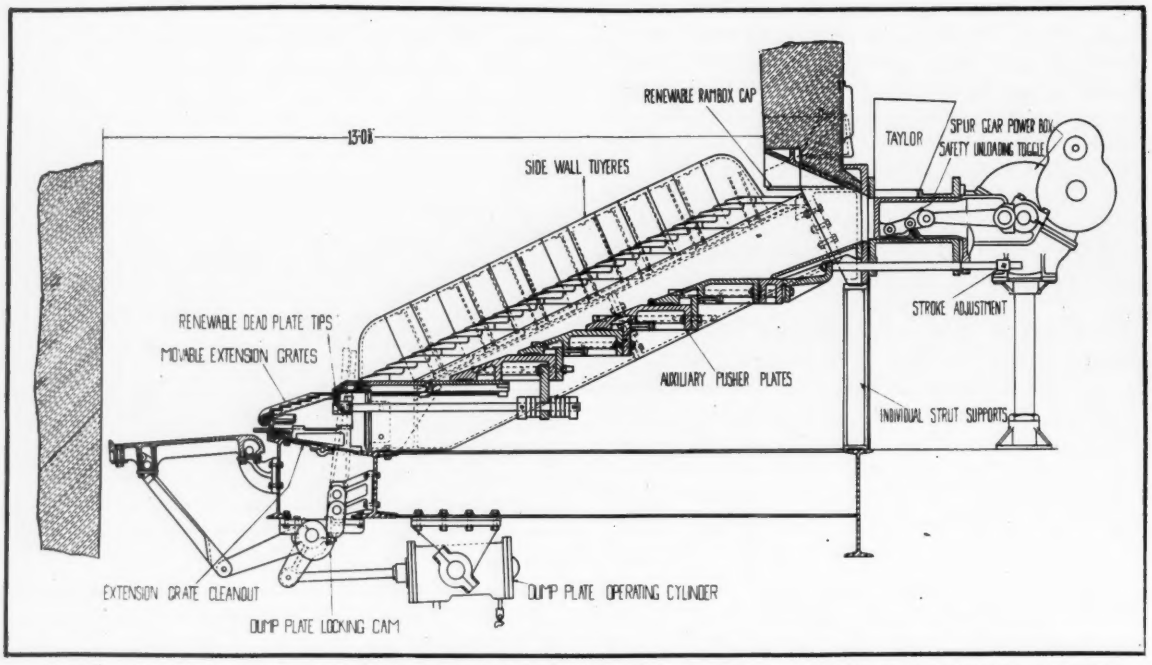

FIG. 1. VARIABLE FEED THROUGHOUT EVERY PORTION OF THE RETORT IS OBTAINED THROUGH THE INTRODUCTION OF AUXILIARY PUSHER PLATES

in all types of secondary pushers heretofore and also gives a graduated feed throughout the entire retort.

With the dump plate type of ash discharge a reciprocating extension grate is used which admits air at low pressure to the lower portion of the fuel bed to burn out the remaining carbon. With the rotary ash discharge type, a similar admission of air is obtained through a stationary curved plate leading to the clinker rolls. Each section of the heavy cast-iron front which forms the assembly base for the individual retorts is accurately machined, and securely fastened in permanent alinement. The front is tied to the remainder of the stoker by the cast iron retort sides. With this design, accurately maintained alinement is possible without resort to the stoker channel which has formerly been used. Each retort is independently supported by a heavy cast-iron strut which transfers the loading to floor beams. This construction renders the stoker independent of the boiler steel work and makes it possible to carry a 24-in. front wall of any height without the

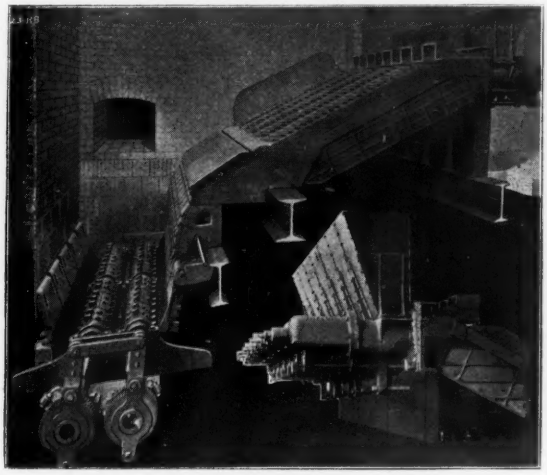

FIG. 2. CLINKER ROLLS ROTATE AWAY FROM ONE ANOTHER AND CRUSH CLINKER AGAINST PLATES. LOWER VIEW SHOWS STOKER EQUIPPED FOR HYDRAULIC DRIVE

rather inadequate devices which have heretofore been resorted to.

Ram boxes are cast solid with no slots. This permits the machining of an accurate round hole, which has not been possible heretofore in boxes in which slots appear. It permits a reduction of the allowable clearance between the feeding plunger and the ram box to much less than that necessary with former designs. Other features of this design make a material reduction on the wear of the plunger and practically eliminate the siftings from the rams. The box can easily be renewed with a minimum scrapping of material.

In order to eliminate the tendency of wet coal to arch, the stoker hopper is designed with the sides of the hopper throat as nearly straight as possible. A small gate is placed in the front of the hopper over each ram, providing easy access in case of any obstruction in the hopper.

On the outer end of the feeding plunger a flange is carried which drives the secondary feeding mechanism. In this plunger is a collapsible toggle which can be adjusted to release at any desired pressure. This entirely eliminates the use of shearing pins or other devices which have heretofore been used at this point to protect the feeding mechanism from obstructions in the fuel. It is so designed that the toggle will automatically reset on each inward stroke and if the obstruction remains in place, a small amount of coal will be continuously fed which will tend to remove it.

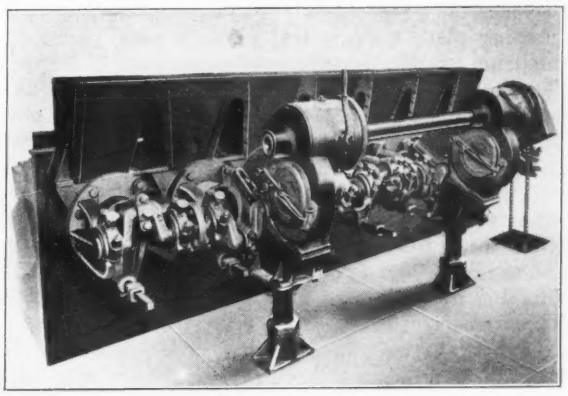

FIG. 3. PLANETARY GEAR REDUCTION PERMITS 50 PER CENT VARIATION IN TRANSMISSION RATIO

For the operation of the hydraulic stoker, the Hele-Shaw pump is used. This pump is of the variable delivery reversible discharge type and is driven by a constant speed motor, with the speed of the stoker rams controlled by variation of the stroke of the pump. Reversal of the pump discharge and consequently of the stroke of the stoker rams is controlled by an automatically reversing valve actuated by the pressure in the system.

It has been common practice for a number of years to use the worm gear reduction for drive on multiple retort stokers. For the new design a drive is used consisting of all machine cut spur gearing which has raised the mechanical efficiency from approximately 14 per cent to approximately 75 per cent. All thrust washers, collars and thrust bearings are eliminated as well as stuffing-boxes. The gears are 50 per cent stronger and from their design should give much longer life than those in the worm gear box. The stoker speed shaft drives through a primary planetary gear reduction. By means of this, a 50 per cent variation in transmission ratio is obtained with all gears constantly in mesh, eliminating shifting of gears or clutches. By providing a neutral point, it is possible to drive directly through the boxes where more than one box is used, doing away with clutches and auxiliary shafts. Further to reduce friction, universal couplings are installed in the speed shaft connecting two or more gear boxes, thus taking care of any possible misalinement. The entire mechanism is enclosed in castings and piping which allows a man to stand on the guards without injury. The box is designed to mount a motor directly on it, thus making it possible to remove all drive material from the floor if desired. A shearing pin is provided in an easily accessible location next to the final drive. This enables a much larger pin to be used and makes it more sensitive.

Tuyeres are cast in blocks and are individually mounted, permitting the removal of any one at any point in the stack independently of the ones above and below it.

Dead plates and ram box caps have renewable tips as shown, thus making possible their renewal with the minimum scrapping of material. The extension grate bars can easily be removed. The extension grates can be cleaned of any siftings which may accumulate in them by the opening of a damper from the outside of the furnace while the stoker is in service.

When the stoker is equipped with the steam operated dumping plate a single leaf plate is used, giving the maximum ash discharge area when the plate is dropped. The plate is supported in operating position by a locking cam on the stoker structure proper, thereby eliminating the necessity for any supports in the bridge wall. It is operated by a steam cylinder of ample power controlled by a simple three-way valve placed on an operating plate secured to the boiler side wall. The control of the locking cam is within easy reach from this point and the fireman can readily observe the operation of the dumping plate through the side door while controlling its movement.

Practically all of the larger central station installations of multiple retort underfeed stokers now being made are being equipped with the rotary ash discharge. With this type of ash discharge, boiler and furnace operating efficiency is at least 2 per cent higher than with any other type. This is due to the more thorough burning out of refuse and the maintenance of uniform furnace conditions.

Air at low pressure is admitted to the grinder pocket through this grate. The clinker grinder rolls rotate away from one another against adjustable crusher plates which are so designed that the crusher roll has a breaking effect on small hard clinker masses. If the crusher rolls fail to crush the clinker mass, the clinker can escape without breaking the mechanism. The plates are held by a self-locking mechanism.

New Type Flow Meter for Steam or Gas

Corrects Automatically for Variations in Temperature, Pressure, and, in the Case of Gas, Specific Gravity

With the ever advancing cost of fuel, the necessity for economy in its use increases and to effect this economy it becomes more and more desirable to have some accurate and reliable means of knowing just what is taking place at all times. In the case of the steam boiler, it is necessary to know the rate at which fuel is being consumed and also the rate at which steam is being generated. To effect economy in the use of steam, it is desirable that it be measured at the several points of consumption.

To provide a reliable means of indicating, recording and integrating the flow of steam, water, gas, oil, air, etc., the Hyperbo-Electric Flow Meter Co. has recently developed a flow meter which automatically corrects for all variations in the condition of the fluid to be measured.

This meter consists essentially of three units: The source of pressure difference, the meter body and the recorder as indicated in Fig. 1. The source of pressure difference, instead of being of the orifice or pilot tube type, consists of an elbow which fits into the pipe line where any standard or extra heavy elbow will fit. The section, however, instead of being a quarter segment of a circle is in the form of a rectangular hyperbola as shown in Fig. 2. In this elbow, the cross-sectional area gradually increases to the plane of symmetry and then decreases. These proportions are such that there is a definite relation existing between pressure, velocity and centrifugal force, consequently no eddy currents are produced as in the circular elbow. The centrifugal action causes a pressure difference between the outside and inside radii of the elbow that is proportional to the velocity and consequently, to the rate of flow. The coefficient of proportionality is constant for all rates of flow and can be calculated from the dimensions of the elbow; it is independent of local piping condition.

Pressure difference thus obtained is applied to the meter body, which consists of a vertical cast steel cylin-

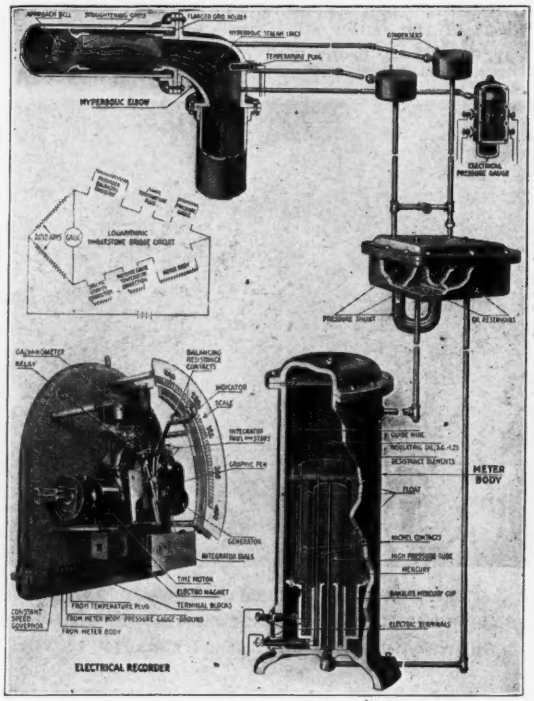

FIG. 1. DIAGRAM OF STEAM FLOW-METER ASSEMBLY

der closed at both ends. One of the pressure pipes enters at the top of the cylinder and the other connects at the bottom with a short pipe rising part way through the center of the cylinder. In the base of the body is an insulated annular cup filled with mercury. Above this the cylinder is filled with an insulating oil, in which rides a hollow float carrying a graduated series of vertical contact wires. These wires are connected in series through a set of resistances through which an electrical current flows. As the float rises, due to increasing pressure differential, the contact wires are lifted out of the mercury, cutting in more and more of the resistance. In this way the total resistance through the meter body bears a definite relation to the pressure difference at the elbow and hence to the flow.

Two electrical connections are led from the meter body to the electrical recorder such as shown in Fig. 3, which may be located at any convenient place, as much as several miles away since resistances, only, are meas-

ured. Here the resistance of the meter body and that of the correction elements is balanced in a Wheatstone bridge circuit and this balance actuates an indicating device which may be calibrated as desired.

Inasmuch as the quantity of fluid flowing in the pipe is affected by variations in pressure and temperature, and, in the case of gas, specific gravity, correcting devices are used to take care of these variations. The pressure in the line acts on an electrical pressure gage which operates on the principle of a mercury manometer with one end closed. Electrical contacts in the tube are joined by suitable resistance elements which are made a part of the Wheatstone bridge circuit. Static pressure is interpreted by the recording mechanism as a proportionate correction on the meter readings.

By the use of a temperature plug, changes in temperature cause changes in resistance. Elements of two materials with different resistance temperature coefficient gives the required correction.

FIG. 2. RECENT INSTALLATION OF FOUR 12-IN. HYPERBOLIC ELBOWS

The regular Wheatstone bridge having four legs, one of which is the balancing resistance, is capable of handling only three variables. To handle more than this number and also to provide an evenly graduated scale, a direct reading indicator, graphic chart and integrator, a logarithmic Wheatstone bridge is used in which the various resistances are made proportional to the logarithm of the variables to be taken into account. The sum of these logarithmic resistances and hence the product of the factors which they represent may thus be obtained.

Current for the Wheatstone bridge circuit is supplied by a small motor generator set which is accurately governed for speed. To the motor shaft is also geared the mechanism for operating the indicator, graphic pen, the chart and the integrator.

Any unbalanced condition which may occur in the Wheatstone bridge circuit deflects a small double throw the neutral position and actuates a small double throw single-pole mercury switch, which energizes a solenoid to move the plunger in either direction. The movement of the solenoid plunger meshes a train of gears with the driving mechanism and moves the indicator pointer and with it a set of brushes which make contact on the bal-

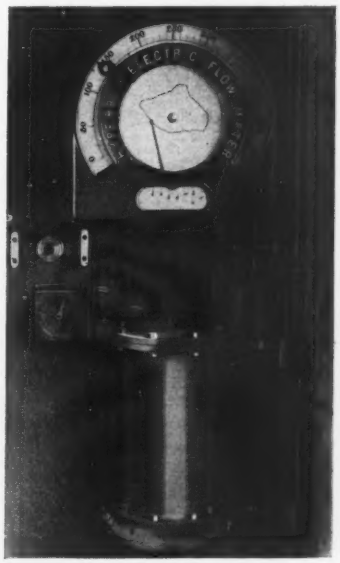

FIG. 3. ELECTRICAL RECORDER AND METER BODY INSTALLATION

ancing resistance, thus cutting in or out resistances which tend to balance the Wheatstone bridge circuit. Meshed directly with a gear on the indicator is the graphic pen which therefore moves in synchronism with the indicator. The integrating mechanism is driven through a chain drive from a gear which is driven by a pawl which rotates once every 5 sec. The engagement takes place at a standard zero position and the pawl moves with the gear until it is disengaged by a stop on the indicator arm. Thus each movement of the pawl is proportional to the indicated flow and this quantity is integrated for every complete revolution of the driving pawl.

The integrator, as well as indicator and recorder may be calibrated to read in any desired units; pounds per hour, B.t.u. per hour, boiler horsepower or, for gas, standard cubic feet, or value in dollars and cents.

HENRY WOODLAND, secretary and treasurer of the Allis-Chalmers Manufacturing Co., died suddenly at his home in Milwaukee on May 14.

Born in Utica, N. Y., Mr. Woodland at an early age became connected with the New York Air Brake Co. of Chicago. Later he was treasurer of the Gates Iron Works of Chicago. When, in 1901, this company was taken over in the consolidation which formed the Allis-Chalmers Co. he became assistant treasurer of the new organization and afterward its treasurer. In 1916 he was elected secretary and treasurer of the company.

At the time of his death he was also vice-president and a director of the Hanna Engineering Co. of Chicago.

New Car Puller Is Totally Enclosed

WITH a view toward reducing the hazard attendant with the use of open gearing for car pullers, the Stephens-Adamson Manufacturing Co., of Aurora, Ill., has recently developed a totally enclosed vertical monitor type car puller. As shown in the accompanying illustration, this unit has a vertical capstan, which is the only rotating part exposed, the motor and planetary gearing being enclosed by a steel case.

For driving the capstan a 7½-hp., 1800-r.p.m. vertical motor is used, the capstan speed being 17 r.p.m.

HIGH SPEED VERTICAL MOTOR DRIVES CAPSTAN THROUGH ARRANGEMENT OF INTERNAL AND EXTERNAL GEARS

This speed reduction is made possible by the use of an arrangement of internal and external gears. The rope speed is 40 ft. per min. and he pulling capacity is 5000 lb. The weight of the unit complete is 2000 lb.

Brooklyn Engineers' Club Elects New Officers

AT THE ANNUAL meeting of the Brooklyn Engineers' Club held at their Club House, 117 Remsen St., Brooklyn, N. Y., on May 10, the annual report of the Board of Directors was received, and officers were elected for the year ending May 8, 1924. The club is making good progress, with a membership of about 450. The new officers are as follows:

President—Linford S. Stiles, chief engineer, Brooklyn Union Gas Co.

Vice-President—Calvin C. Hough, structural engineer, B. R. T.

Secretary—Joseph Strachan, highway engineer, Brooklyn Borough.

Treasurer—W. H. Wharton, construction engineer, B. R. T.

Directors—P. P. Farley, consulting engineer to Borough President of Brooklyn; F. E. Cudworth, engineer with P. McGovern Corporation; J. B. French, consulting engineer; W. J. Shea, engineer with N. Y. City on Staten Island Tunnel; and P. B. Bie, mechanical neer with Electric Bond & Share Co.

News Notes

HAROLD M. TOOMBS, formerly master mechanic for Morris & Co.'s Chicago plant, has taken the position of chief engineer for the Western Felt Works, Chicago.

E. S. FITZ, formerly general superintendent of the Houghton County Electric Light Co., Houghton, Mich., is now engineer in the Power Station Betterment Division of Stone & Webster, Inc., Boston, Mass.

WEBSTER MFG. CO., of Chicago, announces the appointment of Robert T. Pierce as manager of its New York Sales Office at 90 West St. He succeeds the late Glen N. Porter, whose death occurred March 31.

JOS. W. HAYS is just completing the organization of a corps of consulting combustion engineers to be known as Jos. W. Hays and Associates. The headquarters of the organization will be Michigan City, Ind.

STANDARD HARDWARE & SUPPLY CO. of New Orleans, La., is now acting as sole distributor of Metric packings in Louisiana and Mississippi at Memphis, Tenn. E. C. Atkins & Co. is now handling the Metric line. Both of these organizations are carrying a large stock of all of the standard styles.

HERBERT L. FISHER is now doing appraisal work with Stone & Webster, Inc., Boston, Mass. Mr. Fisher was formerly resident engineer with the Goodyear Tire and Rubber Co. and later with the St. Croix Paper Co., as assistant engineer of hydraulic construction, and later with the J. McCormick Construction Co.

CONVEYORS CORPORATION OF AMERICA, Chicago, Ill., announces the appointment of the Pittsburgh Machine Products Co., Oliver Building, Pittsburgh, Pa., as district representatives. The Pittsburgh organization will handle the sale of American steam jet ash conveyors, air tight doors and cast iron storage tanks, in Western Pennsylvania and the Northwestern part of West Virginia.

RAYMOND G. HUTCHINSON has resigned his position as chief engineer of the Michigan Copper & Brass Co. Mr. Hutchinson was with The American Brass Co. for 18 yr., and from 1917 to 1921 superintendent of its Buffalo Branch. For several years before going to Buffalo, he was located at main office, Waterbury, Conn., as plant layout engineer, specializing on process work, efficiency and conveying equipment.

RAWSON COLLIER, until recently general sales manager of the Central Hudson Gas & Electric Co., has joined the organization of Dwight P. Robinson & Co., of New York. Mr. Collier was for 5 yr. a member of the firm of Collier & Brown, consulting engineers, Atlanta, leaving this firm to become connected with the Georgia Railway & Electric Co. Here his work covered 16 yr., during which time he was connected with practically every department in the company. At the time of leaving, he was general sales manager of the company. Mr. Collier is a graduate of the Massachusetts Institute of Technology, and for a number of years has been prominently identified with the work of the

National Electric Light Association, the American Institute of Electrical Engineers, the American Gas Association and the Illuminating Engineering Society.

NOTICE HAS recently been received of the removal of Link-Belt Co.'s Pittsburgh branch office from its old quarters at 1501 Park Building to the new and more commodious offices at 335 Fifth Ave. T. F. Webster, manager of the Pittsburgh office, says that larger space and the more convenient location was imperative because of the extraordinary volume of business transacted during the past year, which promises to remain in full swing at least for the coming fiscal year.

STONE & WEBSTER, INC., has received a contract from the Ford Motor Co. for the construction of a 10,000-hp. hydroelectric power plant on the Menominee River, near Iron Mountain, Mich. The same company is just starting the construction of a combined hydroelectric and steam power plant for the Ford interests at High Dam, St. Paul, Minn., and is also constructing a manufacturing plant adjacent to High Dam, one of the buildings of which will have 23 acres of floor space under one roof.

PITTSBURGH VALVE, FOUNDRY & CONSTRUCTION CO., Pittsburgh, Pa., has announced the following appointments: R. J. Cooper as its California representative with offices in the Monadnock Block, San Francisco, Calif.; Robert M. Spurlock, of Shreveport, Louisiana, is in charge of the Louisiana territory; J. B. Purser, with headquarters at Charlotte, N. C., as district sales representative in that territory; and The Burdick Pensinger Co., of Kansas City, Mo., as representatives in that territory.

WASHINGTON WATER POWER CO., which recently acquired the property of the Okanogan Valley Power Co., has awarded a contract to the Pelton Water Wheel Co., for furnishing a 2500 hp. double-runner cylindrical-case reaction turbine, to operate under an 80 ft. head. This unit will be installed at the Similkameen River Plant of the power company at Oroville, Washington. It will resemble in general design the Pelton turbine of the same capacity now operating at the plant, which was built for Okanogan Valley Power Co. in 1919.

A COURT DECISION of interest to hydraulic engineers, manufacturers of water-power machinery, and others interested in hydroelectric power development in this country and Canada, has been handed down by Judge Westenhaver in the U. S. District Court for Northern Ohio, sitting in Cleveland. In this decision, Judge Westenhaver affirms the validity of the basic Johnson penstock valve patent, and finds the Wellman-Seaver-Morgan Co., of Cleveland, guilty of infringement, in the suit brought by the William Cramp & Sons Ship & Engine Building Co.

PLANS for the erection of a super-power generating station for northern New Jersey, which project has been pending for some time, were outlined recently by Thomas N. McCarter, president of the Public Service Corporation.

This 400,000-hp. plant, which will be situated on a 100-acre tract in the Kearny meadows, will be financed partly by the sale of $14,000,000 in 6 per cent gold bonds. Work on the first 160,000-kw. section will start immediately and will cost $20,000,000.

According to plans, the new plant, which will be financed and built by the Public Service Electric Power Co., will be leased to the Public Service Electric Co., which will distribute power according to the regular basis now in use by that company. This will mean that the new company will be under the jurisdiction of the Public Utilities Commission.

WESTERN STATES GAS & ELECTRIC CO. has awarded a contract for building a 72-in. butterfly valve to the Pelton Water Wheel Co. This valve will operate under a head of 65 ft. and will be installed at the head of the penstock at the power company's new Eldorado plant near Placerville, Calif. It will be designed for both direct and remote control, and for electric motor and hand operation.

DEVELOPMENT of New York's water power resources was discussed recently at Washington at a conference between the Federal power and New York State water power commissions. Afterward Attorney General Sherman, of New York, declaring that the purpose of the meeting was to ascertain the position of the Federal commission on all controversial issues, said the Federal body "confirmed to a great extent our interpretation of its constitutional powers and limitations."

SMITH PAPER CO., of Pittsfield, Mass., is to erect a new power plant for its Niagara and Centennial Mills at Lee, Mass. Hydroelectric power is to be generated and the trunk will begin at the bulkhead of the present Niagara mill and extend through towards the Centennial mill, the power plant being erected in the rear of the latter mill. The trunk will be partly in Lenox and partly in Lee, Mass., while the plant will be in the latter town. The Foundation Co., of New York City, has the contract.

JOSEPH G. WORKER, widely known and prominent combustion and stoker engineer, has joined the organization of the American Engineering Co., Philadelphia, Pa., manufacturers of the Taylor mechanical stoker. Mr. Worker is secretary of the Stoker Manufacturers' Association of the United States, and has spent many years in the study of coal burning by mechanical methods and processes. Mr. Worker believes that there are still greater possibilities in our methods of burning coals and is co-author of the book "Mechanical Stokers" on this subject.

ANNOUNCEMENT of personnel and plans of the committee which is to direct a national investigation of the storage of coal in co-operation with the U. S. Coal Commission, the Department of Commerce and the Bureau of Mines is made by the Federated American Engineering Societies. The committee members are:

H. Foster Bain, Director of the U. S. Bureau of Mines, Washington; David Moffat Myers, former Fuel Administrator, New York; Perley F. Walker, dean of engineering, University of Kansas; W. H. Hoyt, chief engineer of the Duluth, Missabe and Northern Railway, Duluth, Minn.; S. W. Parr, professor of applied chemistry, University of Illinois; Edgar S. Nethercut, secretary of the Western Society of Engineers, Chicago; Roy V. Wright, editor, New York. The chairman is W. L. Abbott, chief operating engineer of the Commonwealth Edison Co. of Chicago.

Catalog Notes

PRACTICAL FACTS ABOUT BELTING is the title of a publication, bound in convenient loose-leaf form, now being distributed by the Chas. A. Schieren Co., of New York City. The book, which is a practical manual on belting and power transmission, is based on the Schieren company's experience in belting and transmission engineering and was compiled by R. C. Moore, secretary and chief engineer of the company. It includes a discussion of the different types of drives; practical facts about belting; such as belting rules and ratings, horsepower ratings, care and operation; proper methods of joining ends of belts; alinement of drives; moist conditions and effective means for overcoming them; V and round belting; selecting the right belt for the drive; data on how leather belts are made; plant layout showing methods for the most economical arrangement of drives; proper sizes and arrangement of shafting in the plant; and locating the motors.

METALLIC PACKING is the title of a bulletin which has been issued by the Crane Packing Co., of Chicago, Ill. Development and correct application of metallic packing to surface condensers, heaters, evaporators and inter-coolers is discussed. It is contented by packing condenser tubes with metallic packing and thus bonding them in good electrical contact with the tube sheet, tube life may be prolonged and troubles due to disintegration through eletrolytic action eliminated. It is also stated that experiments have shown that tubes of standard U. S. Navy hardness will not be deformed by the packing stresses even though the tubes have been annealed at a temperature of 650 deg. C.

SYNCHRONOUS MOTOR Drive for Ammonia Compressors is the title of bulletin No. 41,316, which has recently been issued by the General Electric Co., of Scheneetady, N. Y. In this bulletin, development of ice making machines is discussed after which a method of analysis for conversion of a distilled water ice plant to an electrically driven raw water plant is presented. It is pointed out that the rapid increase in electrically driven ice plants has been due largely to the use of slow speed synchronous motors. During the period from 1913 to 1920 the actual killowatt-hour consumption of ice and refrigerating plants in Chicago alone has been increased from 8½ to nearly 52,000,000 kw.-hr., according to a statement made in this bulletin.

UNIFLOW IMPROVED RETURN TUBULAR BOILERS are described in bulletin 23A, recently published by the Lebanon Boiler Works of Lebanon, Pa. This boiler differs from the ordinary horizontal return tubular boiler in the special arrangement of the tubes which is said to give a uniform circulation of the water during heating, with consequent quicker steaming and a reduction in the size of the boiler for the same rating.

VIEWPOINTS ON THE value of waterproofing compounds for concrete and cement mortar are given in a bulletin entitled Integral Waterproofing, distributed by the Truscon Laboratories, of Detroit, Mich. This bulletin consists largely of a reprint of an article by Samuel Very, architect, which was originally published in Architecture. It is shown in the bulletin that waterproofing compounds are necessary because of the fact that concrete is not properly graded and mixed on the job. For that reason the consensus of opinion among architects seems to be that waterproofing compounds are essential for jobs which are subjected to hydrostatic pressure.

EVERLASTING VALVES are described in a booklet which is now being distributed by the Scully Steel & Iron Co., of Chicago.

THROUGH FIRE WITH THERMOLITH is the title of a new folder now being distributed by Harbison-Walker Refractories Co., of Pittsburgh, Pa.

WM. W. NUGENT & Co., of Chicago, Ill., has issued a bound set of bulletins illustrating and describing all of the Nugent products which include various types of oiling and oil filtering systems.

TYPE OD SAFETY-FIRST Fuse Box is the subject of Leaflet 20,005 just printed by the Westinghouse Electric and Manufacturing Co. at East Pittsburgh, Pa. This fuse box is for use on circuits of 1 to 100 amp. and 75 v.

CURVES SHOWING the results of an acceptance test of a municipal Diesel engine plant at Crowley, La., are presented in a leaflet which is being distributed by the Fulton Iron Works Co., of St. Louis.

WHERE BETTER TURBINES ARE BUILT is the title of a bulletin recently issued by the Kerr Turbine Co., of Wellsville, N. Y. In this bulletin the facilities of the Kerr organization for building turbines are described and the features of the turbines discussed.

THE CUTTER CO., of Philadelphia, has recently issued an interesting 100-page booklet, entitled "Protection Up to Date." It is well illustrated and is devoted to a discussion of the relative value and application of fuses and circuit breakers, with particular reference to equipment manufactured by the Cutter Co.

AUTOMATIC CONTROL of combustion is explained in a bulletin entitled A-Jacks High Pressure Steam Damper Regulator recently issued by the National Regulator Co., of Chicago. In addition to explaining how the system works some of the design features of the A-Jacks regulator are discussed.

BULLETIN No. 41,316, recently prepared by the General Electric Co., is devoted to a brief treatment of the development of ice making machines with suggestions as to the trend of progress. The bulletin lists a method of analysis for conversion of a distilled water ice plant to an electrically driven "raw water" plant.

LINK-BELT CO., of Chicago and Philadelphia, has recently issued an instructive book on "Electric Hoists and Overhead Cranes." Going further than the usual catalog, this new book tells, in print and picture, of the practices and methods employed by users in widely divergent fields. For instance, the practices of a sewer contractor in Maryland, who used a hoist for removing dirt, and the methods employed at a ship building plant in Texas which employed the same means for moving and placing timbers, are illustrative of the wide range of activities covered. Copies of Book No. 480 are obtainable from the Link-Belt Co.'s headquarters in Chicago or Philadelphia, or from any one of its branch offices.

Sparks from the Advertising Pages

Where Buyers and Sellers Meet

Keeping Up With the Times

A few warm days following a backward season and young plants almost leap from the soil, from seeds that have lain dormant in the ground until it seemed they would never sprout.

In like manner the affairs of men seem to suddenly grow and fructify after they have lain dormant for months and years.

Such a "growing time" is the present era of rapid business development with evidence of its remarkable activity on all sides.

As in the smallest garden or the largest farm, so in the life of the individual or of the greatest organization, useful growth occurs only where soil has been prepared and seeds planted.

Ideas are seeds, but it takes deeds to cultivate them and provide conditions for greatest growth.

Some men are satisfied to yield to the influence of warm days and sit down and watch things grow. To others warm days are the very time for redoubled activity in cultivating, planning and preparing for the harvest.

To meet rightly the demands of the present period of industrial activity is a more difficult problem for individuals and institutions than to overcome the difficulties of the so-called dull times.

Growth calls for growth—from the activities of today spring the necessity of preparing for the conditions of tomorrow.

Power plant men must have the vision and the initiative to work farther ahead than most others.

It was the faith of the most progressive that inspired plans for the great power plants now running and to which one addition after another is being built.

Such faith calculates every factor and then plants while the ground is cold, cultivates when times are easy and harvests abundantly when others reap the weeds of disappointment.

Improvements in machinery and equipment for generating steam and electricity even in recent times have been no greater than the improvement represented by the modern tractor-drawn gang plow over the plow hewn from a crooked tree.

Progressive power plant men are now putting all their energy and vigor into their work. They are seizing every opportunity to improve their knowledge of the most modern methods, machines and equipment.

These are the men who will be called to the operating command of new and enlarged power plants. These are the men who are planning still greater and more efficient plants.

In season and out, increasing personal knowledge always pays. Boom or no boom, investment in machines and equipment that increase power and decrease its cost of production pay adequate dividends.

Pseudo economists who are now speculating on the probable length and extent of the present era of expansion are like the farmers and gardeners who lean on their hoes and discuss the probabilities of tomorrow's weather conditions.

Real leaders are working with brain and body to take full advantage of what their faith tells them is bound to come to those ready to receive it.

Here in the pages of POWER PLANT ENGINEERING are the seeds of growth for its readers and their power plants. Here are the latest and best in the ways and means to keep up with the times not only as they are today but as they will be tomorrow.

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

AIR COMPRESSORS.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Bury Compressor Co., Erie, Pa.
Dean Bros. Co., Indianapolis, Ind.
De Laval Steam Turbine Co., Trenton, N. J.
Gardner Governor Co., Quincy, Ill.
Ingersoll-Rand Co., New York.
Worthington Pump & Machinery Corp., New York, N. Y.
Yeomans Bros. Co., Chicago, Ill.

AIR FILTERS.
Midwest Steel & Supply Co., Inc., New York, N. Y.

AIR SEPARATORS.
United Machine & Mfg. Co., The, Canton, Ohio.

AIR WASHERS.
Badger & Sons Co., E. B., Boston, Mass.
Cooling Tower Co., Inc., The, New York.
Spray Engineering Co., Boston,

ALARMS, HIGH AND LOW WATER.
Hills-McCanna Co., Chicago, Ill.
Huyette Co., Inc., The Paul B., Philadelphia, Pa.
Northern Equipment Co., Erie, Pa.
Reliance Gauge Column Co., Cleveland, Ohio.
Williams Gauge Co., The, Pittsburgh, Pa.

ARCHES, BOILER COMBUSTION.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Detrick Co., M. H., Chicago.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Jointless Fire Brick Co., Chicago.
Liptak Fire Brick Arch Co., Chicago, Ill.
McLeod & Henry Co., Troy, N. Y.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

ASH CONVEYING SYSTEMS.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
Conveyors Corp. of Amer., Chicago.
Detrick Co., M. H., Chicago.
Jeffrey Mfg. Co., The, Columbus, Ohio.
Link-Belt Co., Chicago, Ill.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

BABBITT METAL.
Magnolia Metal Co., New York.
Scully Steel & Iron Co., Chicago.

BAROMETERS.
Taylor Instrument Cos., Rochester, N. Y.

BEARING METAL.
Magnolia Metal Co., New York.
Strong, Carlisle & Hammond Co., The, Cleveland, O.

BELT CONVEYORS.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
Goodrich Rubber Co., The B. F., Akron, Ohio.
Jeffrey Mfg. Co., The, Columbus, Ohio.
Portable Machinery Co., Passaic, N. J.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

BELT DRESSING.
Cling-Surface Co., Buffalo, N. Y.
Crandall Packing Co., Palmyra, N. Y.
Dixon Crucible Co., Jos., Jersey City, N. J.
Stephenson Mfg. Co., Albany, N. Y.

BELTING.
Goodrich Rubber Co., The B. F., Akron, Ohio.
New York Belting & Packing Co., New York, N. Y.
Quaker City Rubber Co., Phila.
Voorhees Rubber Mfg. Co., Jersey City, N. J.

BELTING, SILENT CHAIN.
Link-Belt Co., Chicago, Ill.

BELT LACING.
Bristol Co., The, Waterbury, Conn.
Detroit Belt Lacer Co., Detroit, Mich.

BLOWERS, FAN AND FURNACE.
Carling Turbine Blower Co., Worcester, Mass.
Coppus Engineering Corp., Worcester, Mass.
De Laval Steam Turbine Co., Trenton, N. J.
Ingersoll-Rand Co., New York.
Perfection Grate & Supply Co., Springfield, Mass.
Terry Steam Turbine Co., The, Hartford, Conn.
Wing Mfg. Co., L. J., New York.

BLOWERS, STEAM.
McClave-Brooks Co., Scranton, Pa.
Schutte & Koerting Co., Phila.

BLOWERS, TURBINE.
Carling Turbine Blower Co., Worcester, Mass.
Moore Steam Turbine Corp., Wellsville, N. Y.
Wing Mfg. Co., L. J., New York.

BLOWERS, TUBE.
Bayer Co., The, St. Louis, Mo.
Diamond Power Specialty Corp., Detroit, Mich.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

BOILER BAFFLES.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Edge Moor Iron Co., Edge Moor, Del.
Erie City Iron Works, Erie, Pa.
Freeman Mfg. Co., Racine, Wis.
Heine Boiler Co., St. Louis, Mo.
Keeler Co., E., Williamsport, Pa.
Page Boiler Co., Chicago, Ill.
Union Iron Works, Erie, Pa.

BOILER SEAM PROTECTORS.
National Boiler Protector Co., Dayton, Ohio.

BOILER SETTING CEMENT.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Huyette Co., Inc., The Paul B., Philadelphia, Pa.
Jointless Fire Brick Co., Chicago.
King Refractories Co., Inc., Buffalo, N. Y.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York, N. Y.

BOILER SETTINGS.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Jointless Fire Brick Co., Chicago.
King Refractories Co., Inc., Buffalo, N. Y.
McLeod & Henry Co., Troy, N. Y.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York, N. Y.

BOILER SKIMMERS.
Sims Co., The, Erie, Pa.

BOILER TUBES.
Scully Steel & Iron Co., Chicago.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 182

Engineer Co., The, N. Y.
Johns-Manville, Inc., New York.
Jointless Fire Brick Co., Chicago.
King Refractories Co., Inc., Buffalo, N. Y.
Quigley Furnace Specialties Co., Inc., New York, N. Y.

BOILER CAP CLEANERS.
Paragon Power Specialties Co., Hartford, Conn.

BOILER COMPOUND.
Boiler-Kote Co., The, Chicago.
Dearborn Chemical Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.
Paige & Jones Chem. Co., Chicago, Ill.

BOILER COMPOUND FEEDERS.
Hills-McCanna Co., Chicago, Ill.

BOILER COVERING.
Celite Products Co., New York.
Quigley Furnace Specialties Co., Inc., New York, N. Y.

BOILER FEEDWATER PURIFYING APPARATUS.
Graver Corp., E. Chicago, Ind.
Griscom-Russell Co., New York.
Paige & Jones Chem. Co., Chicago, Ill.
Permutit Co., The, New York.

BOILER MOUNTINGS.
Lunkenheimer Co., Cincinnati.

BOILERS.
Babcock & Wilcox Co., N. Y.
Badenhausen, Phillips, Philadelphia, Pa.
Brownell Co., The, Dayton, O.
Casey-Hedges Co., The, Chattanooga, Tenn.
Connelly Boiler Co., The D., Cleveland, Ohio.

BOILER WALL COATINGS.
Boiler-Kote Co., The, Chicago.
Johns-Manville, Inc., New York.

BOOKS AND SCHOOLS.
Audel & Co., Theo., New York.
Hays School of Combustion, Chicago, Ill.
Stumpf Una-Flow Engine Co., Inc., Syracuse, N. Y.

BRIDGE CRANES, ORE AND COAL HANDLING.
McMyler - Interstate Co., The, Cleveland, Ohio.

BRUSHES, DYNAMO & MOTOR.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, GRAPHITE.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, WIRE.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

BUCKET ELEVATORS.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
Link-Belt Co., Chicago, Ill.
Webster Mfg. Co., The, Chicago.

BUCKETS, CLAMSHELL.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
McMyler - Interstate Co., The, Cleveland, Ohio.

BUCKETS, ORANGE PEEL.
McMyler - Interstate Co., The, Cleveland, Ohio.

CALORIMETERS, GAS RECORDING.
Precision Instrument Co., Newark, N. J.

CARRIERS, PIVOTED BUCKET.
Webster Mfg. Co., The, Chicago.

CASTINGS.
Fuller-Lehigh Co., Fullerton, Pa.
Hills-McCanna Co., Chicago, Ill.
Hooven, Owens, Rentschler Co., The, Hamilton, Ohio.
Neemes Bros., Inc., Troy, N. Y.

CEMENT, ASBESTOS.
New York Belting & Packing Co., New York, N. Y.

CEMENT, HIGH TEMPERATURE.
Boiler-Kote Co., The, Chicago.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Jointless Fire Brick Co., Chicago.
King Refractories Co., Inc., Buffalo, N. Y.
Quigley Furnace Spec. Co., Inc., New York, N. Y.

CEMENT, IRON.
Smooth-On Mfg. Co., Jersey City, N. J.
Strong Mach. & Supply Co., N. Y.

CHAINS, DRIVE.
Jeffrey Mfg. Co., The, Columbus, Ohio.
Link-Belt Co., Chicago, Ill.

CHAIN WHEELS.
Babbitt Steam Specialty Co., New Bedford, Mass.

CHIMNEYS.
American Chimney Corp., N. Y.

CLAMSHELLS.
Williams Co., G. H., Erie, Pa.

CLEANERS, BOILER TUBE.
General Specialty Co., The, Buffalo.
Huyette Co., Inc., The Paul B., Philadelphia, Pa.
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburgh, Pa.
Pierce Co., The Wm. B., Buffalo, N. Y.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.
Roto Co., The, Hartford, Conn.
Scully Steel & Iron Co., Chicago.
Self Cleaning Strainer Co., Chicago, Ill.

COAL AND ASH HANDLING MACHINERY.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
Conveyors Corp. of Amer., Chicago.
Detrick Co., M. H., Chicago.
Jeffrey Mfg. Co., The, Columbus, Ohio.
Link-Belt Co., Chicago, Ill.
McMyler - Interstate Co., The, Cleveland, Ohio.
Portable Machinery Co., Passaic, N. J.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago, Ill.

COAL CRUSHERS.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
Fuller-Lehigh Co., Fullerton, Pa.
Jeffrey Mfg. Co., The, Columbus, Ohio.
Pennsylvania Crusher Co., Philadelphia, Pa.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago,

COAL STORAGE EQUIPMENT.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
Jeffrey Mfg. Co., The, Columbus, Ohio.
Link-Belt Co., Chicago, Ill.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

COAL WEIGHING & MEASURING EQUIPMENT.
Webster Mfg. Co., The, Chicago.

COCKS, AIR AND STEAM.
Dart Mfg. Co., E. M., Providence, R. I.
Powell Co., The Wm., Cincinnati, Ohio.
Williams Valve Co., D. T., Cincinnati, Ohio.